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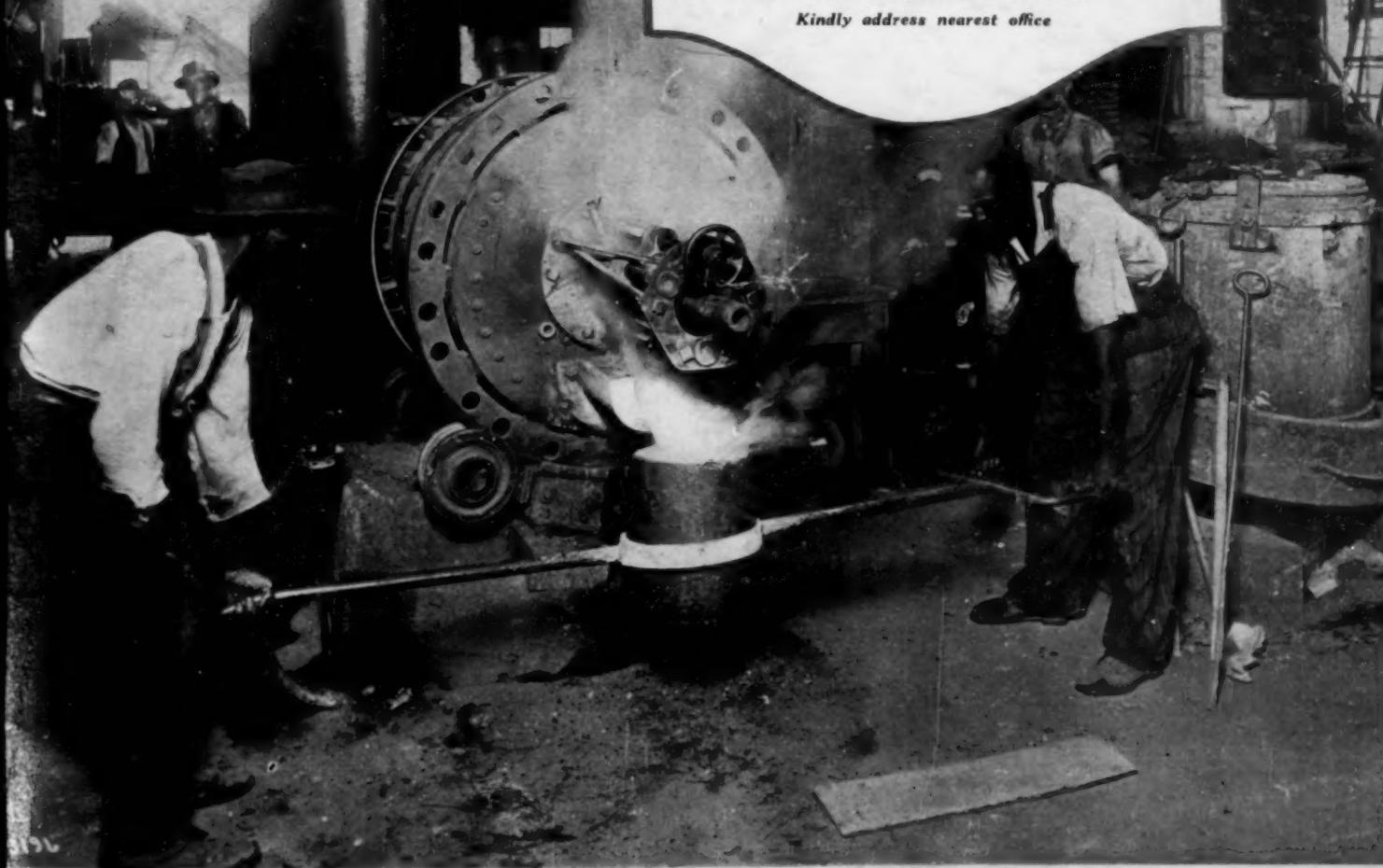
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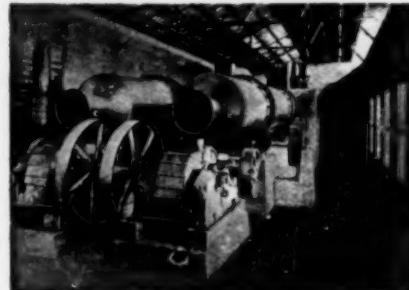
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# CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of  
ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

ALAN G. WIKOFF  
Assistant Editor  
L. W. CHAPMAN  
Western Editor  
CHESTER H. JONES  
Industrial Editor  
J. S. NEGRU  
Managing Editor

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## A Survey of The Chemical Industry

THE chemical industry, as always, is in a state of transition. Roughly speaking, five years ago one would say that the chemical industry required about two dollars of capital invested for every dollar of annual turnover. Now capital requirements are almost doubled for the same turnover. Disregarding war contracts, which were largely made and enjoyed by men who are not ordinarily manufacturers of heavy chemicals, it is doubtful if any other essential industry has maintained so level a curve of prices as this.

The war has not produced new developments in chemical war materials, except, perhaps, in regard to sulphur. New sources chiefly in Texas promise cheaper sulphur, and for the first time in many years the element has been widely used in the place of pyrite and other metallic sulphides in the production of sulphuric acid. This, however, was rather due to shortage of iron pyrites than to competitive prices. It remains to be seen whether the sulphur producers can or will adjust their prices to compete with those ores under future normal conditions.

Muriatic, nitric and acetic acids were all used in very large quantities during the war, but the war did not perfect or revolutionize any process for them in this country.

Practically all the war plants built under Government auspices are closed. They were not planned for industrial use, and many of them unfortunately were not even happily designed for industrial advantage. Whether these plants can ever work themselves out of the category of junk aggregates is a serious question. At present they are incomplete and idle or in process of dismantling, and their prospects are not rosy.

No official effort has been made in this country toward the unification of chemical industry during or since the war, although in England there has been a marked tendency in this direction. In Germany all of their war developments were laid out with a view to improving the condition and co-ordination of chemical industries after the war. There is a curious psychology in this. Nobody enjoys making a dollar more than the typical American, but nobody cares so little for it after it is made or is less anxious to keep it than he. At the same time, if anyone has the courage to venture his wealth in an enterprise that has been organized by the Government, and succeeds in his venture, suspicion is immediately aroused. His profits are resented, and the officials of the Government who planned for just such industrial success are condemned. So it is fair to say that our Government has given substantially no consideration to permanent industrial development, and that the people of the country will therefore receive no benefits from it.

The Germans in the past have gone ahead faster than we have. This is not due to better chemists; it comes rather from better chemical understanding in high places, and greater concentration of resources.

Chemical research in the U. S. A. during the war period has been confined largely to the organic field, and since Germany was in control of a great part of that industry, it has consisted principally in trying to follow Germany. Otherwise the war has hindered rather than promoted true research.

As to markets and plant operations, the tremendous momentum of production at the time of the Armistice in November, 1918, was arrested by February, 1919, and in March and April of that year trade was very dull. By May and June it had picked up, and now everybody is busy. This is more than can be said of England and France, where, in neither country, are the peace plants operating at full load.

Industrial chemistry has made a big forward stride during the past year, not so much through the development of new processes or through any remarkable improvement of established processes, but rather through a silent and unspectacular invasion of industries that have heretofore gotten along with but little assistance from the chemist or without an intensive application of the principles of chemical engineering. There has also been evidenced an extension and broadening of the scope of the work performed by the chemist and physicist in chemically controlled industries and an added importance placed upon the technical positions in industrial organizations. Thus we note an expansion of the personnel of research departments and an extension of their investigations to cover the whole field of industrial activity, and also find the chemist employed in the smaller plants as an addition to the operating staff.

That this should take place during a year in which industry as a whole has marked time awaiting a more favorable opportunity for expansion and development augurs well for the future position of the industrial chemist and of the chemical industries.

## Electrometallurgy In 1919 and Afterward

THE year just passed was an active one for the electrometallurgical industries. The beginnings of large improvements were numerous and important. In fact, one feels that the electrometallurgical processes are "coming into their own."

In the iron and steel industry the introduction of electric melting and refining furnaces in steel plants was more active than ever before. This industry has already far outstripped the crucible steel process, and if it was not so well fitted to work duplex or triplex with the bessemer converter or open-hearth furnace, or both, we might say that it was a potential successor to these

standard steel apparatuses. Works experience with the electric steel furnace is certainly short and limited in comparison with other processes, yet it is the most rapidly developing improvement in the whole steel industry.

In Scandinavia the electric reduction of iron ores to pig iron is on a sound commercial basis, and large extensions are already under way, such as at Lulea, where six of the largest size (2500 kw.) furnaces are being erected. It looks as if the knell of the iron blast furnace is about to sound in Sweden, and the situation is likely to spread to other countries similarly situated as to power and fuel cost.

The electrolytic refining of iron, for the commercial production of very pure iron, made its commercial débüt in France in 1919. Details are not yet published, but the plant is invaluable for producing the basic material for the highest quality of special alloy steels.

The synthetic production of cast iron of carefully controlled quality from the superabundance of steel scrap from munition machine shops was a war development in which electric furnaces were the necessary apparatus. A description of several fine plants erected for this purpose in France has just been distributed by the American Electrochemical Society, written by the chief director of this industry in France, CHARLES A. KELLER. How much of this industry will survive under post-war conditions is not certain; we believe that a considerable part of it is bound to survive as a stable industry.

Automatic heating, hardening and tempering furnaces electrically heated and controlled have attracted great attention in the past year. The leading American designer and constructor of these apparatuses has rapidly devised one type of furnace after another, designed to replace the trained and experienced workman by the impeccable machine with its superhuman electric control, and served by a common laborer. The steel industry stands to benefit largely in the near future from these innovations, and other metal industries will likewise share the advantages of these electrical improvements.

In the non-ferrous metal industries 1919 was characterized by the rapid introduction of electric melting furnaces in place of melting in crucibles or open-combustion furnaces. Crucibles cost twice as much and are not half as lasting as they once were; the electric furnace had a great opportunity, and it was grasped. It is hardly conceivable that the industry can or will back-track. Fifty or more electric furnaces were erected in a single brass-producing city (Bridgeport, Conn.), and all the other brass makers in the country are either looking on with interest or have determined to follow suit. America is leading the world in this development, and the brass and other related industries of other countries cannot do otherwise than imitate our methods and follow our lead.

Altogether, just from this fragmentary review of what is only a part and not the whole field of electrometallurgy, the advocates of this branch of science and industry must feel proud of the rapid progress made and the innovations introduced in 1919. It is only a fraction of the progress which will be recorded in this line for this year, for the door is just opening, and the general introduction of electrometallurgical methods bids fair to work revolutions in many of the metal industries in 1920.

### The Alkali Industry During the Past Year

**I**N REGARD to alkalis there is substantially nothing new in technology. Before the war \$12 a ton was a more or less standard price for soda ash, and Europe could not compete with domestic manufacture in this territory. Now labor and steam power have become very uncertain factors both here and abroad, but it hardly seems likely that we need fear foreign competition in the home market for soda. Business in soda ash and caustic has been very similar to that of sulphuric acid: great demand during the war, followed by a heavy slump after the Armistice, and now plants are running nearly to capacity again. It should be remembered that many big caustic plants have lately doubled and some even trebled their capacity, but in spite of that they are running nearly full time.

This is partly explained by exports to the Scandinavian countries, which are the natural customers of Germany; to South America, formerly supplied by England and Germany; and to France and Spain and elsewhere. These markets have been obtained by American producers, not by low prices or cheap production, but because there has been no competition. Germany does not seem to have soda for export as yet, which may be due to labor troubles, or coal shortage, or to difficulties in transportation. The same may be said of England, so that when European manufacturers start to go after that trade, to get back what was formerly theirs, it may be that production will have to be curtailed. It will be largely a question of manufacturing costs.

There is considerable talk of a combination of the Haber process for making ammonia with the Solvay process in Europe. For the Solvay process it will be recalled that brine, ammonia and limestone are needed, and by this combination of processes the ammonia would come direct from the Haber plant, enter with CO<sub>2</sub> and water as ammonium bicarbonate into reaction with salt in which acid radicals are exchanged. Then sodium bicarbonate precipitates from the ammonium chloride solution, and this liquor, on treatment with caustic lime, sets the ammonia free. The ammonia may then be treated with sulphuric acid to form ammonium sulphate and sold as fertilizer.

We fail to see any very great advantage, because in the Solvay process the ammonia is mostly recovered so that the total amount required for renewals is not very great. Then, too, the two products are respectively an industrial and a fertilizer material, and the demands for the two are not adjusted to joint manufacture.

Occasionally there are rumors of a reintroduction of the Leblanc process. Some three years ago there were two or three such plants still in operation in England, and a very few similar works along the Rhine in Germany. There is none in this country, but the gossip usually arises from the fact that there are great deposits of sodium sulphate in Arizona, New Mexico and California. As thenardite, which is anhydrous Na<sub>2</sub>SO<sub>4</sub>, it is sometimes 98 per cent pure. When a cheerful promoter sees the deposits and reads the price of Glauber's salt as a drug or as a chemical need in the dye baths of the textile mills or in glass works he usually has visions of great wealth. These industries being all far away from the source of supply, to encourage production his next thought is the Leblanc process for soda! For this the materials

are brine, sulphuric acid, limestone and coke. While limestone is sometimes available it is the absence of coke and the problem of freights that usually kills the proposition. Such an undertaking, however, is a possibility.

In regard to potash, we have now a producing capacity of nearly 100,000 tons K<sub>2</sub>O per year, or a little less than half of our requirements before the war. This can be extended, provided there is profit enough in the business, or provided technical research advances rapidly enough. It is likely to be two or three years before some establishments are shaken down to economic production. In addition to this, the problems of fuel, labor and freight are all in a state of flux.

The most promising prospects are certain California and Nebraska lakes; the greater deposits being in California. Here we have very strong natural brines in a hot, dry region. This is as rich as German or Alsatian products, dug out and brought up from many hundred feet underground. Now it is up to American technologists to get this salt by the aid of the sun and artificial evaporation as cheap as Germans can mine it, and it seems as though this were possible. It is also up to American producers to refine it at the same costs as Europeans can. The chemistry of the refining, including the separation of borax, and all other ingredients, is all worked out.

From 1000 to 5000 tons each are coming in from other sources, some of which may be materially increased. For lack of space we shall merely mention them: Dust from cement mills, beet sugar waste, molasses alcohol waste, Utah alunite, and Wyoming leucite. Two iron blast-furnaces are making potash recovery at present. This source may have considerable development in a couple of years. Working over the green sands of New Jersey may also become an important factor in the future, but they are not producing as yet. Kelp is practically dead for the present. The trouble was the cost of handling 90 per cent water which it contains when harvested, and the large amount of unprofitable organic matter to treat before the potash could be produced. The United States Government has an experimental plant in operation, with a view to developing enough useful byproducts from the kelp and thus to put the industry upon a commercial basis.

### Gold and Silver

#### Metallurgy in 1919

THE conditions that have prevailed in the gold industry during the past year have approximated stagnation. Probably not a mine operated throughout 1919 at full capacity, and all have faced increased costs. It is true that some reduction in the cost of many mining and milling staples has been experienced, but the benefit which might have been derived from these has been offset by the shortage of labor and its falling efficiency.

Naturally, the result has been retrenchment. Metallurgical developments have been such as have been dictated by the necessity of paring expenses to the bone; generally speaking, they have been refinements of existing practice rather than additions to known methods or to underlying principles. This condition, and the state of mind it inevitably produces, has also been in evidence in the technical press and the publications of the national societies. Passing these in review, we recall few of more than ordinary interest.

CROWE and LENNOX have described work done with Chilean mills at the Portland. It would appear that they have developed a mill that is superior to earlier designs, but it is not so clear that it has merit enough to threaten either the stamp- or the ball-mill. Ball-milling has contributed nothing new during the year, other than a steady improvement in technique and a more general understanding of the limitations of this type of machine. The stamp-mill operators have had an unsatisfactory experience with alloy steels, forced on them by war conditions as a substitute for hammered iron in such parts as camshafts. We understand that the steels have failed dismally, but feel that the failure may be redeemed when the manufacturers take time to give intelligent study to the exacting requirements of the stamp-mill. Several new screening devices, as the Mitchell and the Maxton, have been offered during the year.

ALLEN, in the *Engineering and Mining Journal*, discussing general tendencies in metallurgical practice, interested us in his insistence that this country has not wholly appreciated the advantage of gravity-leaching of finely crushed sand, suggesting by inference that our "all-sliming" work has been carried to an unwarranted extreme. We think there is much good sense in his argument. Sand-leaching is cheap; it is effective. Moreover, its possibilities have not been exhausted.

As an illustration, a single point may be instanced. For effective extraction, one of two conditions is essential. Usually, ample time must be allowed; sometimes it is sufficient that a certain minimum quantity of solution be applied. When the first condition prevails, the question of leachable depth of sand becomes of interest. Given clean classification, the depth may cover a considerable range without affecting leaching rates. Leaving out of consideration such factors as saving in cost of installation, increased washing time, etc., there remains the fact that, if 10 per cent more sand can be treated in a vat, extraction will be effected with 10 per cent less solution, and consequently with enrichment of effluent solution and reduction of all losses except the cyanide actually destroyed by the ore. Close attention of the problem is warranted.

The work of the copper men in leaching is of increasing interest to cyanide operators. The large scale of operations, the mechanical devices used, the manipulation of solutions, all carry valuable suggestions to practitioners in the older branch of hydrometallurgy.

CROWE'S process is a success, proclaimed as such not only by its continued introduction but also by criticism of the merits of its claim to letters patent. Of the soundness of the points raised against these claims we are not convinced, but that they should be made at all is excellent indorsement of the value of the process.

Of collateral interest is the publication by WHITE, in South Africa, of a method for the determination of oxygen in cyanide solutions. He apparently overlooked Sir WILLIAM RAMSAY'S work on the same subject, published eighteen years ago. Indeed, RAMSAY seems not only to have originated but to have pointed out the weaknesses of the method, which impresses one as being of rather limited application, too readily influenced by slight irregularities in the sampling and subsequent manipulation.

South Africa has been sharing our experience with unrest and disorganization of business; technical matters are for the moment of secondary importance. A new wage scale, with provision for a six-day week, has recently been negotiated on the Rand.

The great demand for silver has stimulated production everywhere, subject, of course, to the universal limitations imposed by unsatisfactory business conditions. BRYAN is again the prophet, and we have wondered at times, with the metal quotations before us, whether he may not have been, after all, an unduly modest conservative.

This reviving interest is being evinced by the reopening of old mines and camps, and interesting metallurgical problems may arise from these. Cyanidation will no doubt be the most favored method, as it has been almost the only one practiced in recent years and wider margins will extend its economic field. But in the bonanza days of the last century many ingenious processes were developed. In addition to the old Patio process, the Washoe, Von Patera, Augustine and Russell processes may be mentioned, to name but a few. Exhaustion of rich ores or falling prices of bullion led to the complete elimination of these methods. It is of interest to speculate whether the current market will bring back any of the old processes, rehabilitated with the machinery and equipment of the present day, and drawing on the experience of cyanide operators for supervision.

Then, too, the experiments in volatilization, quoted by LYON and RALSTON, and the work in this field by the staff of the Chief Consolidated, suggest that this radical innovation has possibilities. If the vagaries of the chloridizing furnace can be controlled, there may be a future for these methods.

#### Developments in Ceramics During 1919

**A**LMOST without exception ceramists have confined their efforts to adapting their technology to the available types of clays. They have never, except in a few individual cases, attempted to do much chemically with their raw material. Before the war great quantities of foreign clays were imported into this country. Little real effort was made to obtain them from among the vast and varied domestic deposits until the foreign supply was cut off. How successful were the clay geologist and ceramist has been frequently reported and is undoubtedly familiar to all.

However, the accomplishments of the clay chemist have been extolled with a weak voice indeed! It has almost become a dying one, for the work of our analytical friends in ceramics has furnished insufficient as well as only indirect guidance in this industry, where physical properties are mainly wanted and which can be controlled directly by physical tests.

Some valuable chemical developments in ceramics appear to have been accomplished during the past year in a laboratory located almost within hearing distance of the din from the narrow streets of the New York financial area. A practical process has been developed here for making a lean clay fat—a bond clay out of pure kaolin, which gives promise of a new era in refractories and the many industries depending upon them. The technical details cannot be described at present, but will be during the coming year.

In the fused silica industry progress can be noted at home as well as abroad. Since 1901 the variety of

products has increased simultaneously with a decrease in prices. Large acid plant installations were made during the war and two domestic concerns are now operating on a small scale. The bulk of this material has been imported from England, but with the impending prohibitive duty once enacted, we will soon be fusing our own sand and use more fused silica equipment than can even be anticipated under present conditions.

#### Petroleum Industry In 1919

**B**UT a few years ago the low valuation of that undesirable by-product of the petroleum refinery, gasoline, gave impetus to the development of the internal combustion engine. The latter in turn was to create markets of inconceivable magnitude for the many petroleum products then practically unknown, ranging all the way from gas to pitch, surely a desirable substitute for the market of lighter products, ever becoming more circumscribed by the displacement of the candle and oil lamp with more modern methods of lighting.

In the past year the major products of the petroleum refineries—gasoline, lubricating oils, asphaltic residues, and coke—have largely been utilized so as to get more miles of transportation out of our several million motor cars and trucks. Just as it was the function of the lubricating oils to reduce the power lost by friction within the machine, so it was that of the asphaltic residue to produce less resistant roads and that of the coke to reduce alumina to aluminum for use in the fabrication of bodies and motor parts of less weight. All three of these factors helped to reduce the tractive energy required and therefore actually have a gasoline equivalent of considerable magnitude. An improvement in the technology of any one of these four products can be said to have a bearing second to none in regard to public convenience and pleasure.

Gasoline made by the cracking process is not stable and upon standing partly polymerizes into products which clog the carburetor, unless a considerable proportion of saturated hydrocarbon is mixed with the destructively distilled product. It has consequently been thought that the new cracking processes were of limited application. Some investigators have anticipated this difficulty by working out hydrogenation processes for building up the saturated hydrocarbon content. However, it has been found that by making prompt delivery of the destructively distilled gasolines, they will usually be consumed before sufficient time is given for the polymerization to take place.

None of the cracking processes gives the most desirable conditions for getting maximum yields. Temperature, heat input and pressure are not so difficult to control, but they must now be maintained below the ideal, due to the safety limitations of the equipment used. Considerable work along these lines is being done which gives promise of development of great importance. The oil fraction to be cracked is passed through a bath of molten lead. Evidently, the pressure is easily controlled by the head of metal maintained above the oil inlet. Very great pressures can thus be obtained without danger of ruptured containers and conflagrations. The temperature is controlled by regulating the heat applied to the container of the metal in conjunction with which the rate of the oil feed and its dispersion governs the flow of heat into the oil.

Asphaltic residues are usually brought to the required specifications of melting point, penetration, or tempera-

ture susceptibility by proper mixing of bases and blowing with air. It has been found that a better product is made by using a very high rate of air input and shorter heating periods than has generally been adopted hitherto.

In one of the large Eastern refineries, a segmental still-head has been designed so that the coke zone can be readily exposed and the deposit removed mechanically. Stills thus equipped will not have to stand idle for days to be cooled down to a temperature at which men can enter to clean them. Many asphalt and other stills containing bituminous solids will eventually be equipped with some such type of segmental plate and mechanical cleaner in preference to carrying excess equipment for peak operation.

During the year the petroleum refining companies formed a Petroleum Institute which will undoubtedly have considerable influence in many aspects, legislative, technical or economic. At the present time new specifications governing the use of fuel oil are being discussed. The Institute keeps its members informed as well as obtains and makes known their opinions on points at issue. It is planned to organize a technical section which will afford men the long and much needed opportunity to meet, swap ideas and return to their plants with their minds opened and stimulated.

#### **Review of the Year's Advance in Rubber**

THE shifting from a war to a peace basis has been accomplished by the rubber industry with no great difficulty. This was due chiefly to the fact that rubber has a wider range of application in the arts of peace than in war. In 1917 and 1918 the rubber factories were running at minimum production and every effort was put forth to aid our Government. Peace brought a decrease of production in some lines, but the effect was just the opposite in rubber. The stocks of all the major companies began to rise. Production organizations were expanded, and since then practically all companies have been hard pressed to fill their orders. This is particularly true in the tire business, which had been considerably under the ban due to the restriction of crude rubber imports.

One of the most gratifying results of the war has been the better appreciation of the value of the chemist and chemical engineer. This lesson has apparently been well learned by the rubber industry. During the past year practically every company has either installed or enlarged its laboratory, and the tendency is to give more weight to the opinions of its chemists. The day of the rule-of-thumb compounding is nearly over. His place is being taken by the rubber chemist, whose duty it is so to combine science and common sense that products may be improved and cheapened, while at the same time production may be increased and a uniform quality maintained.

Another achievement of the year has been the reduction in the number of tire sizes for pleasure cars. Through co-operation between the Society of Automotive Engineers and the tire makers many unnecessary sizes have been eliminated. The resultant saving in cores and molds has been enormous.

There is a marked tendency for a wider application of the cord principle in tire construction. There are now no 5-in. tires which are not cords. It is predicted that before long all sizes, even down to 3 in., will be made in this way. While cord tires have a higher

initial cost than fabric, they do give a lower cost per mile and more comfortable riding, which is due to the greater pliability of cord casings over those of fabric. This increased pliability has permitted the development of pneumatic truck tires, which are now past the experimental stage and are being manufactured in quantity by several large companies. There is a growing tendency to equip all long-haul trucks with pneumatics and to use solid tires only on very good roads and for short hauls. This is due to the fact that trucks so equipped can average 30 to 35 miles per hour over a long trip.

Because of the failure of electrically driven street cars adequately to care for the traffic in many large cities, more and more attention is being paid to the operation of buses which are simply large trucks with special bodies in which seats are provided for from 25 to 75 persons. Such buses, equipped with pneumatic tires, are comfortable and make very good time. Since no tracks or trolley wires are required, they are free to operate on any street. There is a great saving in initial expense and upkeep, and since only one man is required to operate most of them, there is a saving in labor as well. Keen students of the traction problem say that the street car is doomed.

The growing of long staple cotton equal to the best Egyptian or sea island varieties in Arizona is of particular interest to American tire manufacturers. The success of the project is now assured and many thousand more acres of former desert land will soon become productive.

In tubes the consensus of opinion seems to favor increased pole size. It has been found that if the diameter of the tube more nearly equals that of the casing its life is longer. In other words, the lower the strain the tube is under when the car is still the better it will age.

American tube makers are showing great interest in antimony sulphuret. It is admitted by most rubber chemists that a properly compounded antimony tube made with rightly prepared sulphuret is absolutely the best tube that has been made to date. The American branch of a French rubber company enjoys a national reputation because of the high quality and long life of its tubes. There are now approximately six firms in this country making antimony sulphuret, and antimony tubes are being manufactured by quite a number of rubber companies.

The pioneer work of EATON, GRANTHAM, DE VRIES and others in producing fast-curing rubber of high quality is now bearing fruit. At least two of the large rubber companies are producing it on their own plantations and using it in their compounds. There is an increasing tendency among rubber growers to pay more attention to selective breeding and like problems with a view to making the *Hevea* tree more productive.

In the accelerator field hexamethylene tetramine is now almost as extensively used as thiocarbanilide was a few years ago. Another accelerator that has recently come into general knowledge is the reaction product of dimethylamine and carbon disulphide, dimethylamine-dimethyl-dithiocarbamate, which is the most powerful curing agent known to date. A quarter of 1 per cent of this substance will give a good cure in three minutes heating to 140 deg. C. If this same stock is made into a cement and the accelerator added in benzol solution, the whole mass will

set to a very stiff vibrant jelly in about a week's time at room temperature. There are as yet no practical applications of this accelerator, but one may reasonably expect the development of a line of self-curing cements and patches at no very distant date.

There has been very little labor trouble in this industry, chiefly because rubber workers are well paid and the large majority of them are home-owning Americans. Several firms require their foreign-born workmen to become American citizens or quit. In many factories there is a healthy spirit of co-operation between the men and the management which has brought about a good appreciation of each other's responsibilities. There is no room for Bolshevism here.

The coming year should be a very fruitful one for the rubber industry. The demand for rubber goods of all kinds was never greater, not only at home but abroad. Materials are available in quantity and labor is willing. These are certainly the principal factors necessary for prosperity.

### Hydrometallurgy and Pyrometallurgy

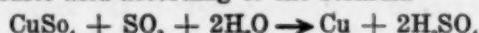
#### Of Copper in 1919

**N**EW smelter construction appears to be centered in South America, and the Andes Mountains bid fair to witness a building boom such as occurred ten years ago in Arizona. Strangely enough, each one of the four leading copper producers is engaged in the design, if not in actual construction, of new and larger plants. Braden has completed plans for a new blast-furnace plant some five miles below its present mill site, concentrates to be transported by rail or aerial tram. Cerro de Pasco has started on the construction of a new smelter at Oroya, some distance below La Fundicion, the site of its present one, planned and built some 15 years ago. Its new plant (which will probably not operate before 1922) will have two blast and two reverberatory furnaces, and will make about 100 million pounds of copper annually—somewhat more than the present installation gets with nine smaller smelting units. Chuquicamata is engaged on a project which calls for doubling its present output—the same leaching system will be utilized, and the extension will be on the same site. Andes Copper has its preliminary work on its property at Potrerillos well in hand, the metallurgical details having been carefully worked out by LAIST at Anaconda and the mechanical design for a 12,500-ton unit nearly complete in all respects. Briefly the scheme for the oxidized capping will consist of crushing to  $\frac{1}{2}$  in., leaching by downward percolation in rectangular concrete tanks containing one day's ore receipts, precipitation by pig iron or  $\text{SO}_2$ , and refining by melting down under bone ash.

Of this new construction it is seen that over half is devoted to leaching—to hydrometallurgy—and the conclusion is safe that from now on the sulphuric acid leach will be given careful consideration by those contemplating treatment of low-grade oxidized ores. As a process for roasted sulphides it is not so attractive. For instance, ROGERS at Anaconda has found that table tailings from old dumps containing 0.7 per cent copper can be reground and reduced to a 0.2 per cent tail by flotation as cheaply as the same material can be roasted and dissolved in its leaching plant, and the former method is now practiced using either one section exclusively or distributing the available sands throughout the mill.

But there is a range between straight sulphide ores and straight oxide ores where the losses in either process may be too much to countenance—in fact much work is being done, particularly in Arizona, on combined methods which will catch the oxidized copper comprising the bulk of the tailings values. If the ore contains few acid-consuming materials—a point impossible to determine from the usual chemical analysis—it would obviously be good engineering to leach coarse material, then grind and float the cleaned sulphides, a scheme which ALDRICH is now operating at Inspiration in a 30-ton experimental mill. On the other hand, the Miami Copper Company, in co-operation with VAN BARNEVELT of the Bureau of Mines, is investigating a scheme for handling mixed ores which entails fine grinding followed by flotation. The pulp is then passed through a large wooden drum against a current of  $\text{SO}_2$ , which leaches soluble copper out as sulphite, changing rapidly into sulphate, however. The whole mass then goes through a very long ball mill, acting not as a grinder but as a precipitator, after which the cement copper is to be recovered by flotation.

Precipitation of copper sulphate presents the most interesting problem in leaching. Some ores may be so fortunately constituted that any contained iron is insoluble; then the solutions may be electrolyzed almost completely without precautions to lower the ferric content and with the simultaneous production of little or no cement copper. On the other hand, manipulation may change the ratio of cement to electrolytic copper. Thus, at New Cornelia, during curtailed production TOBLEMAN found that the longer the time of leach and the lower the corresponding acid concentration, the less would be the amount of impurities dissolved and consequently the greater the proportion of electrolytic copper to cement copper produced, a very desirable condition. On some ores, solutions may become so foul that only a small percentage of copper is removed in one passage through the tanks and that at a low ampere efficiency; this condition, coupled with a high cost of electricity and acid, would make some clean method of chemical precipitation quite attractive. FRICK at Anaconda has therefore worked out the details of precipitation by  $\text{SO}_2$  for the new Andes plant. In this scheme, leaching solutions, thoroughly reduced by liquid  $\text{SO}_2$ , pass through heat interchangers into lead-lined autoclaves, there to be heated to 150 deg. C. under 125-lb. pressure for 4 hours, when half of the metal is thrown out as bright red copper crystals with the generation of sulphuric acid according to the formula



The hot mixture is then discharged through interchangers and thickened; the liquid returned to circuit and the copper dried and furnace refined.

Reverberatory and blast furnace still maintain supremacy in their individual bailiwicks, despite rumors of the latter's demise. Anaconda has cut one of the 51-ft. units into the two 15-ft. stacks from which it sprang, and runs the small one only intermittently, while KUZELL has just doubled the capacity at Clarkdale by a battery of new reverberatories, and other Southern plants have hung up wonderful records for long campaigns. Thus, CLARK at Calumet & Arizona, by widening furnace, raising verb and enlarging uptake, has been able to smelt regularly 700 tons of dry charge daily plus 100 tons of converter slag, with an oil consumption of 0.7 barrel of oil per ton. Large modern

reverberatories are doubtless pre-eminent for smelting fusible fine charges, especially where fuel and silica brick are cheap. On the other hand, a blast furnace has all the best of the argument with refractory, coarse ores, high in sulphur, especially in places where power is relatively cheap and cost of coke not prohibitive. Even fines may be smelted to advantage after sintering or nodulizing, as will be done in Braden's new plant, and introduction of powdered coal through tuyeres bids fair to remove the disability caused by expensive coke.

The soundness of the latter idea seems definitely established. Early in 1918, CAVERS ran a blast furnace at Tennessee Copper for a fortnight, blowing pulverized coal through ten tuyeres on one side of the furnace. But very little coke was charged occasionally, it being replaced by two-thirds its weight in fine coal. This practice was discontinued because of unburned carbon discoloring the acid; but later experiments at International Nickel have shown beyond question that pulverized fuel can replace a considerable percentage of coke, a result confirmed at Cerro de Pasco, by RICHARDS at Garfield and by HAMILTON at Midvale.

VAN ARSDALE and MAIER have published a most important contribution as to the exact condition of copper in furnace slags. To a certain small extent copper sulphide is held as a true solution, but the balance occurs as globules of white metal, floated by attached bubbles of SO<sub>2</sub>, the latter gas formed by reduction of iron sulphide by ferric iron in the slag. Continued settling would not recover either the dissolved or the buoyed metal, and this can only be done by changing the composition of the slag so as to practically eliminate the occurrence of ferric oxide. In the light of this information, data on the operation of the large slag furnace at Anaconda are interesting. Here liquid converter slag is poured through a side door of a reverberatory, banked by high-sulphur calcine and siliceous tailings. Reaction with this material melting along the sides of the bath reduces the magnetite in the converter slag and tailings are dissolved so that whereas the incoming slag carries 4 per cent copper, 63 per cent iron reported as FeO, and 23 per cent silica, the outgoing slag has been reduced to 0.6 per cent copper, 53 per cent FeO and 34 per cent silica.

Anaconda's new Cottrell plant started during the summer, giving good clearance of very fine fume. The relative difficulty and expense of catching fume and dust are vividly exhibited by a comparison of this monumental plant with a little plate treater tucked away in a short section of gas flue at Tooele. In comparison it is only a toy, yet it gets 90 per cent of the dust passing a dust chamber, even when handling gas from twelve McDougalls at 20 ft. per sec. With the problem of how to catch solids now solved, the next to appear in the near future will be how to get rid of the unusual substances which will accumulate and finally saturate the smelter system. How to do it at a profit will at times be subordinated to the compulsion to do it in some way which will create no nuisance or positive danger.

Refineries were left with much war-time excess capacity as well as war-time copper on hand, and it is hardly probable that any considerable plant extension will occur for some years. An interesting possibility for the future is the casting of large ingots to be rolled direct without cooling into rods or sheets in mills built closely adjacent to the furnace refinery, a practice long

standard for blooming mills in steel plants. ANTISELL, at Raritan, has been able to use a high-sulphur Mexican topped oil of high specific gravity in cathode-melting furnaces, without any harmful effects from high sulphur in the resulting wire bars. If electrolytic copper, notoriously sensitive to minute impurities, can thus be melted without slag protection and with impunity with what is commonly regarded as dangerously impure fuel, the harmful effects of SO<sub>2</sub> in furnace gases in other metallurgical operations are possibly overdrawn. It may be remembered that high ash pulverized coal was not suitable for reverberatory smelting on account of an "insulating blanket of fine ash settling upon the slag," until some ignorant person went and used it!

Even in rock-ribbed Michigan are signs of change visible. Needs must, for the Federal Trade Commission's reports show that as a group, Lake copper costs more than that from deep mines or porphyries in the West, even the biggest Michigan companies returning costs of from 16.2 to 16.6 cents per pound, while at the same time the price differential between Lake and electrolytic copper has definitely vanished. Deep mining, low-grade ores and fine concentrates point to a certain revision of Lake practice to that more modern; at least some simple labor-saving devices are necessary purely on account of the continual decrease in number of laborers of the broad-back, narrow-forehead type. The cheapest copper coming from Michigan is probably that reclaimed from regrinding tailings, and it is even possible that the old slag dumps can be made to yield metal more economically than can an ore body 5,000 feet below.

### The Steel Industry's Growth

THE actual commercial capacity of the United States for producing steel ingots crossed the 50,000,000-ton mark in 1919. To secure a basis for computation one must go back to the year 1916, for in none of the three years intervening has there been opportunity to test the industry under fair working conditions. In 1917 and 1918 there were transportation difficulties curtailing the output at one time or another, and in 1919 there was a lack of orders for a large part of the year. The steel ingot production in 1916 was 41,401,917 gross tons. Deducting the estimated production of new capacity installed during 1916, and adding about 80 per cent, to be conservative, of the rated capacities of new installations from January 1, 1916, to January 1, 1920, one reaches a figure slightly in excess of 50,000,000 tons. It seems perfectly safe to assert that given the same operating conditions as obtained in 1916 such a tonnage can be produced.

On the whole, there has always been sufficient rolling capacity to take care of ingot production. The sum total of rolling capacity is always well in excess, as provision must be made for variations in the distribution of demand. Except for the dislocation produced by the rolling of shell steel, with heavy discards, the production of finished rolled steel, in rods, skelp, sheets, plates and shapes, has always run approximately 76 per cent of the ingot output. Hence the capacity in finished rolled steel may be taken at fully 37,500,000 gross tons a year, or 725,000 tons a week. The year 1920 opens with a conspicuous shortage of steel, and with production at 550,000 or 600,000 tons a week, and thus it may be seen readily that making up the shortage is chiefly a case of

bringing production as nearly up to the capacity rate as may be.

Electric steel has made a magnificent record in the past four years. Previously the statistics had given it a little bit of a black eye. It looked bad that production of electric steel ingots and castings should jump from 13,762 tons in 1909 to 52,141 tons in 1910, and then show a lower production in each of the four years following. The excess production in 1910 was chiefly of rails, made for experimental purposes. For many, if not all, other uses the production of electric steel increased in the four years following 1910, with the exception, of course, of 1914, which was an "off" year in practically all respects. The remarkable growth of the electric steel industry is shown by the following production statistics, the figures referring to gross tons:

	Ingots	Castings	Total
1909	13,456	306	13,762
1910	50,821	1,320	52,141
1911	27,227	1,878	29,105
1912	14,147	4,162	18,309
1913	20,973	9,207	30,180
1914	15,458	8,551	24,009
1915	46,348	23,064	69,412
1916	126,048	42,870	168,918
1917	239,632	64,911	304,543
1918	403,068	108,296	511,364

While the war was largely responsible for the rapid increase in the production of electric steel, there has been no retrogression since hostilities ended. Instead there has been much new construction, at a rate not far below that which obtained during the war. The half-million ton output of 1918 is large in itself, but the tonnage is made the more impressive as the output of a young industry when it is observed that the steel industry of the U. S. was regarded as very large at the time the United States Steel Corporation was formed, early in 1901, and that the 1918 output of electric steel is 5 per cent of the output of the entire steel industry just before the formation of the Steel Corporation.

The pig iron producing capacity of the United States, on a fair estimate of actual production under normal operating conditions, not a summation of rated capacities of stacks, is about 45,000,000 tons a year, with a dozen furnaces being built, to add about 2,000,000 tons to production. Output for years past has grown not merely by the erection of new stacks but by the remodeling of old stacks and by apparently slight changes in equipment and methods whereby individual furnaces have materially increased their output.

Statistics have now accumulated for a number of years of the consumption of iron ore, fuel and limestone by blast-furnaces, so that some comparisons may be made. Beginning with 1909 there are complete statistics of the quantities of iron ore, mill cinder, scale, etc., and limestone consumed by the furnaces, while the fuel consumption figures are complete since 1912.

The average iron content of the Lake Superior ores has been going down more or less steadily for about 20 years, partly by reason of the exhaustion of the choicest deposits and partly because expanding requirements necessitated the opening of lower-grade deposits. One might suppose, therefore, that the average ore consumption of the whole industry, per ton of iron made, would increase. The ore consumption was 1.886 tons per ton of pig iron in 1909 and 1.895 tons in 1910, since which year it has been less, and 1918, with 1.853 tons, was almost the lowest year of the ten for which statistics are available. The statistics, however, furnish a plain offset to this, in that while the consumption of mill cinder, scale, etc., was

0.098 ton in 1909 and 0.102 ton in 1910, it was 0.130 ton in 1918. The total of the two was almost constant in the ten years, the maximum being 2.018 tons, in 1911, the minimum being 1.937 tons, in 1917.

Scale is much richer in metallic iron than any of the iron ores available, and scrap is nearly all metallic iron. Taking the industry as a whole, there was practically no choice as to the consumption of scale. Presumably the blast-furnaces consumed nearly all the scale that was produced in rolling steel. As the production of the steel has increased more rapidly than the production of pig iron, a smaller percentage of the total pig iron output being used in foundries, the relative supply of scale has increased at least slightly. The proportions of the charge in 1909 were 95 per cent iron ore and 5 per cent cinder, scale, scrap, etc., while in 1918 the proportions were 93.4 per cent and 6.6 per cent. The increase in the material other than ore may be attributed entirely to an increase in the scale available, which would mean that the blast-furnaces are not using larger quantities of scrap.

Seeing the uniformity of the figures, one might possibly incline to the notion that blast-furnace managers have endeavored to regulate this matter for themselves, using scrap as necessary to get out certain tonnages. It is interesting that in ten years the amount of ferrous material has deviated only slightly from a mean of about two tons per ton of pig iron.

It should be noted that in statistics like these, where simply the totals for the whole country are considered, the declining iron content of Lake Superior ores is balanced, to some extent at least, by two other influences. One is that rich ores have lately been imported to a greater extent than formerly, while another is that the proportion of Lake Superior ore to total ore has increased, and the Lake Superior ore remains of higher iron content than the Southern ores. The total production of iron ore in the United States increased from 51,155,437 tons in 1909 to 69,658,278 tons in 1918, but the production of all ore outside the Lake Superior region was practically stationary, being 9,291,802 tons in 1909 and 9,878,484 tons in 1918.

The fuel statistics are complete only for 1912 and subsequent years. They show, as to the coke furnaces, 2436.5 pounds per ton of iron for 1912 and 2375.2 pounds for 1918. Very small quantities of bituminous coal were used, and weighed in with the coke, the quantities being so small as not to affect sensibly the showing of fuel consumption. Comparing 1912 and 1918, there was a slight decrease in the quantity of ferrous material used, and these two changes are almost precisely in proportion. There is a larger decrease in the consumption of limestone than in the consumption of coke, but very precise comparisons cannot be made because the limestone statistics are not separately given for coke furnaces, the anthracite totals being included.

The general conclusion one may draw from the statistics is that no great change has been occurring in these matters, taking the industry as a whole. At individual plants furnace managers may effect important changes, but the industry as a whole is operating much the same now as ten years ago.

Actual production in 1919, which was distinctly an "off" year, was approximately 30,500,000 tons in pig iron, 33,000,000 tons in steel ingots and 25,000,000 in finished rolled steel, or in the neighborhood of two-thirds of capacity.

# Manufacture of Pure Tungsten Metal—Operations at the Fansteel Products Company

**Smelting and Leaching the Ore—Production of Ammonium Paratungstate, Tungstic Acid, and Oxides—Reduction Operations and Design of Furnaces Used to Secure Pure Metal—Working Qualities of Product—Future Markets**

BY CHESTER H. JONES

FROM comparative obscurity and classification with the rare elements twenty years ago, tungsten has come to take a place among everyday substances in the metallurgical world. It has largely received prominence through use in the steel industry and later in the incandescent electric lamp manufacture. Automobile ignition equipments have also consumed large quantities of tungsten metal for contact points.

We have been accustomed until recent months to think of these substances in the metallic state as powders of varying impurity. The steel industry has called for only a crude refining of the ore; the lamp manufacturers have kept the processes secret and made little attempt to market the fine wire they produce; and makers of tungsten contact points have made no effort to market the pure metals for general application.

It is hoped that by a description of the process of producing pure metal from the crude ore and an outline of the properties of the final and intermediate products the chemical industries may find particular application to supply needs hitherto unfilled.

## TREATING THE REFINED ORE

The wolframite ore is received in 100-lb. bags at the plant of the Fansteel Products Co., North Chicago, the present supply coming from Korea. It is a hand-picked product about pea size ( $Fe, Mn$ )  $WO_3$ , heavy dark gray to black, sub-metallic crystals, orthorhombic in appearance, but actually monoclinic. The material has a hardness of 5 to 5.5; specific gravity 7.1 to 7.55; streak, dark brown to black; opaque, brittle and slightly magnetic. The chemical analysis is about as follows:  $WO_3$ , 73 per cent; tin, 1 per cent; copper, 0.05 per cent; manganese oxides, silicon oxides and iron oxides, 25.95 per cent.

This ore is first crushed in a small jaw crusher and subsequently ground to a coarse brown powder in a

Braun planetary disk crusher. It is then mixed with commercial soda ash in a ratio of one part of  $WO_3$  content to one part of  $Na_2CO_3$ , plus a 15 per cent excess of soda ash. This mixture is placed in a belt-driven Abbé pebble mill, about 1-in. diameter pebbles, and reduced to pass 100-mesh screen.

## ROASTING

The fine mixture is shoveled by hand into a small reverberatory furnace in charges consisting of about 200 lb. of ore to 100 lb. of soda ash. It is hand-rabbed

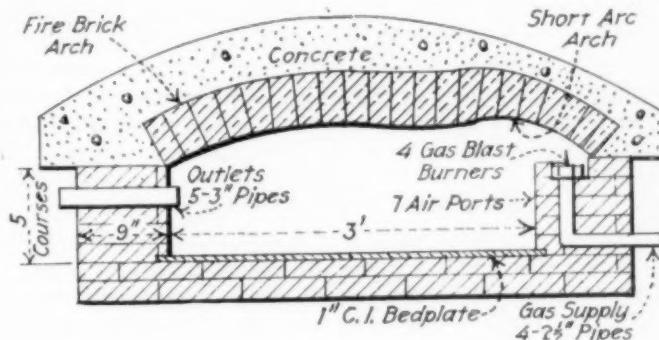


FIG. 2. TRANSVERSE SECTION OF REVERBERATORY FURNACE

at a temperature of about 800 deg. C., just sufficient to convert all the manganese oxide to dioxide during the following main reaction:



The operation requires about 2 hr. per charge. Care must be taken that the temperature does not mount high enough to fuse the mass, which must be kept in a pasty condition. When the reaction is complete the hot material is raked out in cast iron pans to cool.

## DESIGN OF THE FURNACE

The furnace is located out of doors and its general appearance may be noted in Fig. 1. This view shows the five fume outlet holes and the single door, used for charging, discharging and as a rabbling port; with flat pan before the opening ready to receive the finished roast.

The structure is erected on concrete base with concrete roof to protect the brick work from the weather. Length of inside is 5 ft., with 3 ft. width of hearth and five brick courses from floor to point where arch intersects. Fig. 2 shows sectional sketch of furnace. Ordinary fire brick is employed as a refractory, but is unsatisfactory because of rapid deterioration, especially on the floor and side walls where the charge comes in contact with the brick. For this reason a 1-in. cast iron bed plate is inserted over the floor. This resists



FIG. 1. REVERBERATORY FURNACE—OUTLET SIDE



FIG. 3. REVERBERATORY FURNACE. GAS FEED SIDE ON RIGHT

the chemical action of the charge, but is not suitable, as its continual warping and crawling under the temperature changes break up the walls, as can be seen in Fig. 3. In the construction of a new furnace magnesite or dolomite brick should be used.

The gas supply system appears on the right in Fig. 3. Gas is furnished at about 3-lb. pressure and the air blast is maintained by a small positive-pressure blower. The Zander blast burners furnished by the Chicago Pulley & Shafting Co. are imbedded in the brickwork to protect from heat in the main chamber, and the flame near this point is directed downward by the small arch constructed in the main roof.

#### LEACHING THE ROASTED ORE

The cooled matter from the furnace is crushed to pea size in a jaw crusher and taken to the leaching room. Here it is shoveled into wooden tanks 4 ft. in diameter and 4 ft. high, where solution with process water is agitated by wooden mechanical stirrer. The sodium tungstate goes into solution quite rapidly, but the liquor is usually agitated over night to assure complete dissolving. A 2-in. pipe line near the bottom of the tank connects up with a small centrifugal pump, which forces the slurry into a 36-in. Sweetland filter press made by the United Filter Corporation.

The clear filtrate,  $\text{Na}_2\text{WO}_4$ , is discharged through a 2-in. hose to the precipitating tanks. The sludge, consisting of  $\text{MnO}_2$ ,  $\text{Fe}_2\text{O}_3$  and other oxides, is washed in the press and washings returned to mixing tank. When thoroughly cleansed of all tungstate the residue is thrown away. In testing the first solution in the mixing tanks a hydrometer is employed. If a 50 deg. Baumé reading is secured the solution is saturated. It is not allowed to go below 30 deg. Baumé.

#### COMMERCIAL TUNGSTIC ACID

The precipitating tanks are wooden or stoneware tubs about 3 ft. in diameter by 3 ft. high. The clear liquor is heated by live steam jet from hose bubbled directly into the solution. When brought to a boiling temperature the hose is removed and a 20 deg. Baumé solution of  $\text{CaCl}_2$  is added in excess. A white flour-like precipitate of  $\text{CaWO}_4$  is thrown down. This is washed with process water, by decantation, until all the excess chlorides are removed.



The calcium tungstate is baled over to glazed-ware bowls about 3 ft. in diameter and 2.5 ft. deep and a

20-gal. carboy (120 lb.) of commercial hydrochloric acid is added to excess. A stoneware pipe is inserted in the solution to supply the live steam for boiling. The reaction

$\text{CaWO}_4 + 2\text{HCl} = \text{CaCl}_2 + \text{H}_2\text{WO}_4$ , is continued over a period of about 1 hr. The yellow precipitate of tungstic acid is allowed to settle and the excess  $\text{CaCl}_2$  and  $\text{HCl}$  are siphoned off. This acid and chloride solution is treated with lime to obtain  $\text{CaCl}_2$  for the preceding operation.

The yellow precipitate is shoveled to a General Ceramic Co. suction filter, operating under about a 20-in. vacuum, and is repeatedly washed with process water. The resulting product has the following average analysis:

$\text{H}_2\text{WO}_4$	99.53 per cent
$\text{FeO}$	.02 per cent
$\text{Al}_2\text{O}_3$	.05 per cent
$\text{CaO}$	.20 per cent
$\text{SiO}_2$	.20 per cent

This is the ordinary commercial tungstic acid known on the market as Grade A. It is seen to be impure as compared with the required acid.

#### PURIFICATION OF TUNGSTIC ACID

The washed precipitate is removed from the suction filters to the ammonium paratungstate room by hand and dumped into a high enamel-lined steel tank 3 ft. in diameter by 5 ft. This tank is painted on the outside with aluminum paint to resist ammonia fumes. Sufficient distilled water, together with about 5 gal. of concentrated ammonium hydroxide, is added to nearly fill the tank and obtain a 7 per cent solution of ammonium paratungstate.

A 1-in. jet of live steam is added through the hose to bring the solution to boiling. Fig. 4 shows this tank with the steam hose hanging down between the windows.

The hose on the right-hand edge of the tank is connected to a centrifugal pump which decants the liquor to a 12-in. wood-leaf Sperry filter press shown in the foreground. This press is equipped with filter paper between the leaves and the spigots are replaced by glass tubes inserted in rubber corks, as shown emptying into the wooden trough in Fig. 5. The clear filtrate of paratungstate is carried by 2-in. hose shown at the lower right hand of Fig. 4 to 150-gal. enameled, steam-jacketed Elyria kettles. The second ammonia room mentioned later is equipped with Pfaudler kettles.

Reference to the kettle in Fig. 5 will show the steam piping, the liquor hose across the floor from tank to pump and the wooden hood over the evaporating kettles,

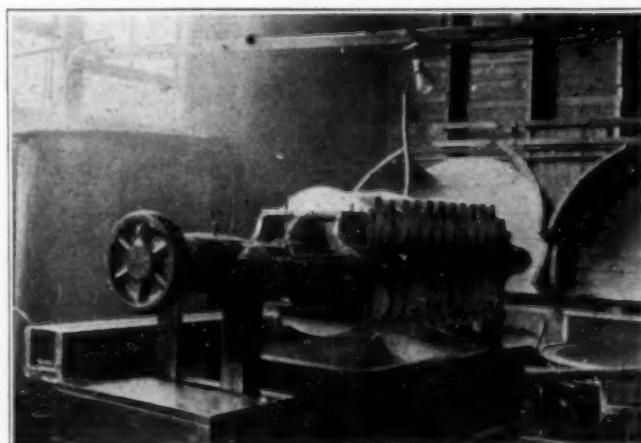


FIG. 4. AMMONIA ROOM, WHERE AMMONIUM PARATUNGSTATE IS MADE

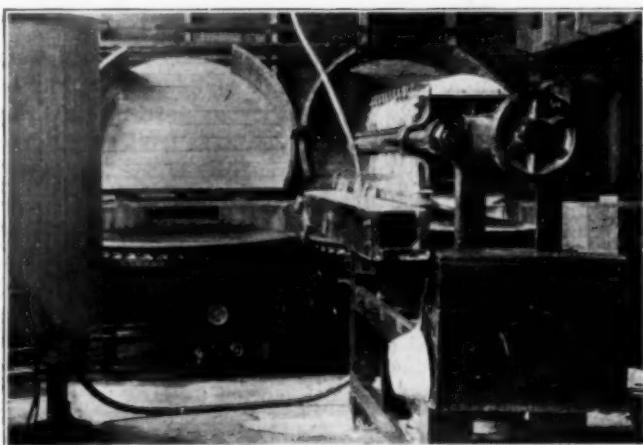


FIG. 5. AMMONIA ROOM SHOWING TANK, KETTLES AND FILTER PRESS

lifted out of place. This hood collects the ammonia fumes during evaporation, which are carried off by an exhaust fan. The rectangular exhaust opening is shown in the wood housing directly back of kettle.

The filtrate is evaporated to a small volume in the pans and dried to a mud in stoneware suction filters and is washed with distilled water. The sludge from the filter press consists of impurities and some quantity of blue mud, ammonium metatungstate. This, together with the filter paper, is saved for the scrap salvage mentioned further in this article.

The white mud, ammonium paratungstate, is removed to the nitric acid room, where 40-lb. batches are placed in the 7-gal. steam-jacketed enamel-lined bowls shown in Fig. 6.

C.P. nitric acid, about 40 per cent solution, is added. The white precipitate is slowly changed to the yellow tungstic acid  $H_2WO_4$ , as the liquor is heated. The color of this product is a much brighter yellow than the original commercial tungstic acid noted at the beginning of the purification process.

The nitric acid fumes collected in the hood shown over the kettles in Fig. 6 are exhausted from the room by a 6-in. General Ceramic Co. stoneware fan direct-connected to a 2-hp. General Electric motor running at 1800 r.p.m. Considerable trouble with the handling of these fumes was experienced until the installation of this apparatus, which has been giving perfect 24-hr. service for a year.

The contents of the kettles are removed on completion of the reaction to two 10-gal. stoneware suction filters, where they are washed repeatedly with distilled water. In spite of the processes through which the tungsten compound has passed it is not yet of sufficient purity for production of the metal, and is therefore taken from these filters and returned to the ammonia room, redissolved as paratungstate, filtered in a Sperry press, evaporated, filtered and washed with distilled water in suction filters and returned to the nitric acid room.

It is again treated with C.P. nitric acid solution, filtered and washed repeatedly in suction filters and dried to give the pure tungstic acid needed for metal production.

#### PURE TUNGSTIC OXIDE

The next operation consists in placing the yellow tungstic acid in No. 6 fused silica crucibles, 44 crucibles per heat, and placing in a gas-fired oven. The tempera-

ture is raised to about 1000 deg. C. and the following reaction occurs:



The resulting tungstic oxide is a light green color due to mixture of  $WO_3$ , yellow, and lower oxides of tungsten, which are blue. The following analyses give some idea of the purity of this product:

#### SAMPLE NO. 1

$WO_3$	99.94	per cent
$Fe_2O_3$	.024	per cent
$Al_2O_3$	.018	per cent
$CaO$	.009	per cent
P	Trace	
$SiO_2$	.010	per cent
S	none	

#### SAMPLE NO. 2

$WO_3$	99.96	per cent
$Fe_2O_3$	.0075	per cent
$Al_2O_3$	.016	per cent
$CaO$	.028	per cent
P	none	
$SiO_2$	none	
S	none	

A very pure tungstic oxide has been produced in small quantities for special purposes with the following analysis:

$WO_3$	99.995	per cent
$CaO$	.005	per cent

The metal tungsten is of higher purity than the foregoing analyses because of volatilization of the impurities. All oxides produced are analyzed and if a content above 0.02 per cent  $Fe_2O_3$  is present they are returned to the process for further purification.

#### RAW MATERIALS USED

The process water enters two Hygeia Filter Co.'s Steward non-agitator filters connected in parallel and is distilled in a 55-gal. Barstead automatic still. A 750-gal. storage tank supplies the requirements for the pure water.

About 40 per cent of the output at the present time consumes scrap tungsten for the raw material. All scrap metal, filter paper, sludge from ammonia rooms, sweepings, etc., is reconverted by ignition in a small gas-fired brass-melting furnace with sodium nitrate to get the soluble sodium tungstate. Thirty lb. of sodium nitrate and 25 lb. of scrap constitute the usual charge. The powdered metal and sludge may be thrown in with a reverberatory charge. The process on scrap then continues as described for the ore.

#### DIFFICULTIES IN CHEMICAL PROCESS

The over-all efficiency of the chemical process is 90 per cent, that is, 90 per cent of the tungsten in the ore

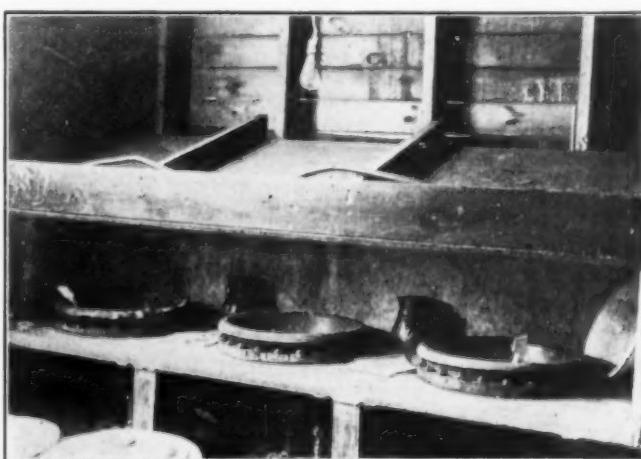


FIG. 6. NITRIC ACID ROOM—STEAM-JACKETED EVAPORATING BOWLS

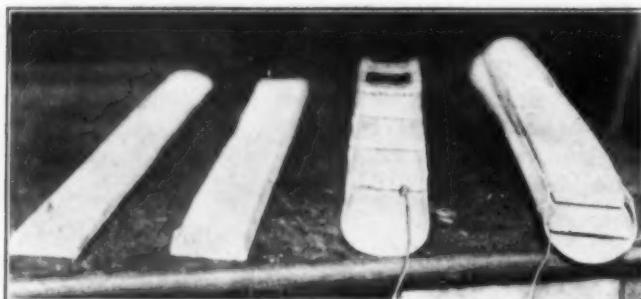


FIG. 7. NICKEL BOATS AND TRAYS FOR FURNACE

is recovered. The greatest difficulty in the work is to maintain absolute cleanliness in each step of the operations. The item that has given the most trouble in this connection is the refractory containers, especially the enamel linings in tanks and evaporating kettles. No enamel lining has been found that will remain perfectly intact under the action of hot acids and alkalis. Alkaline conditions cause chipping of linings, resulting in the presence of iron, silica and silicates in the process. The linings become de-vitrified. These impurities occur in actual combination with the product and not as mechanical inclusions.

When the impurity is carried through to the metal product the physical structure of the sintered bar is weakened to a marked extent. Continual supervision is necessary to prevent this condition.

#### REDUCTION OF $\text{WO}_3$ TO TUNGSTEN POWDER

Until recent years the only commercial methods of reduction were (1) by hydrogen and (2) by use of carbon. The latter was generally employed because of difficulty in control and of completion of reaction with hydrogen. As a result it was impossible to secure pure tungsten. The hydrogen method has been improved upon so that it is now entirely used in the Fansteel Products Co. plant to secure the purest metal obtainable. Ten thousand cu.ft. of hydrogen are consumed daily in the process.

The  $\text{WO}_3$  powder is placed in small nickel trays about 18 in. long, which are stacked in pairs in nickel boats as shown in Fig. 7. The two trays appear on the left; the third object is the nickel boat empty, showing cross-wire supports and wire for pulling out of furnace, and on the extreme right is the boat containing two loaded trays. This charge is placed in a closed-tube type electric furnace, heated to about 1200 deg. at completion of exothermic reaction, through which passes a stream of pure hydrogen. The reaction is as follows:



The tungsten is withdrawn as a gray powder. The excess hydrogen passing out is dried from water content and re-enters the system.

#### DESIGN OF REDUCTION FURNACE (OLD TYPE)

The older type of furnace, still in continuous operation at this plant, is well illustrated in Fig. 8. Each set consists of four tubes with three in operation, the fourth one a spare. Each tube is composed of a quartz member about 5 ft. long, around which is formed the heating element, a coil of nichrome or molybdenum wire. About this element a heat insulating jacket of Sil-o-cel is held in place by a galvanized iron jacket. The quartz tube is attached to water-cooled, cast fittings at each end which are provided with connections to the hydrogen supply and exhaust system.

Single phase current is supplied to each tube at 220 volts, a set of three consuming about 50 amp. on tungsten reduction and 30 amp. on molybdenum reduction. This difference is due to necessity of getting 1200 deg. C. on tungsten and 900 deg. C. on molybdenum. Two sets of the old type furnace consume about 3000 cu.ft. of hydrogen per 24 hours.

When starting up with a new charge the heat must be applied very slowly to prevent fusion of the  $\text{WO}_3$  powder before the exothermic reaction starts. Should this fusion occur, the reduction would be accomplished only on the surface of the mass.

#### NEW TYPE REDUCTION FURNACE

The Fansteel Products Co. has just completed and placed in operation a four-tube tungsten reduction furnace set of entirely new design and larger than those previously operated. The complete outfit consists of the furnace proper, assembly drawing of which is shown in Fig. 9, the water chest beneath the tubes; three calcium chloride towers about 1 ft. in diameter and 8 ft. high for drying the hydrogen from the furnace; complete pyrometer equipment for noting temperature of hydrogen in the jacket of each tube; three glass tubes packed with absorbent cotton to purify hydrogen; one hydrogen pump oil type, manufactured by C. Crowell, and hydrogen pressure tank; together with complete switchboard and control equipment for the heating coils.

The hydrogen supply enters the annular space between the 3-in. and 1½-in. pipe and is preheated prior to entering the furnace by the exhaust in the 1½-in. pipe as seen in Fig. 9. Passing into the space between the quartz tube and the jacket, it is further heated, and finally enters the main tube, passing out near the point of entrance.

The tube is equipped with an additional preheater coil at the right of the drawing with connection terminals as shown on extreme right. Fig. 10 shows the feed end of the furnace with the hydrogen apparatus in the rear. The picture was taken before all the lower piping connections had been made. Peepholes are evident in the doors. Glass-absorbing tube appears in the background beyond door of rear tube. The whole equipment is excellent in design and shows careful workmanship. The operating record should prove a distinct advance in reduction furnace efficiency.

The gray tungsten powder is removed from the furnace after a period of about 7 hr., when it has been reduced to a high state of purity. Analyses are given under tungstic oxide. This powder is then placed under a hydraulic pressure of 300 tons and formed into a bar

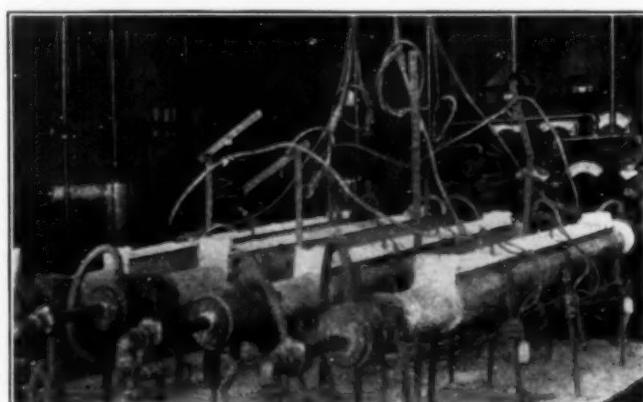


FIG. 8. OLD TYPE REDUCTION FURNACE

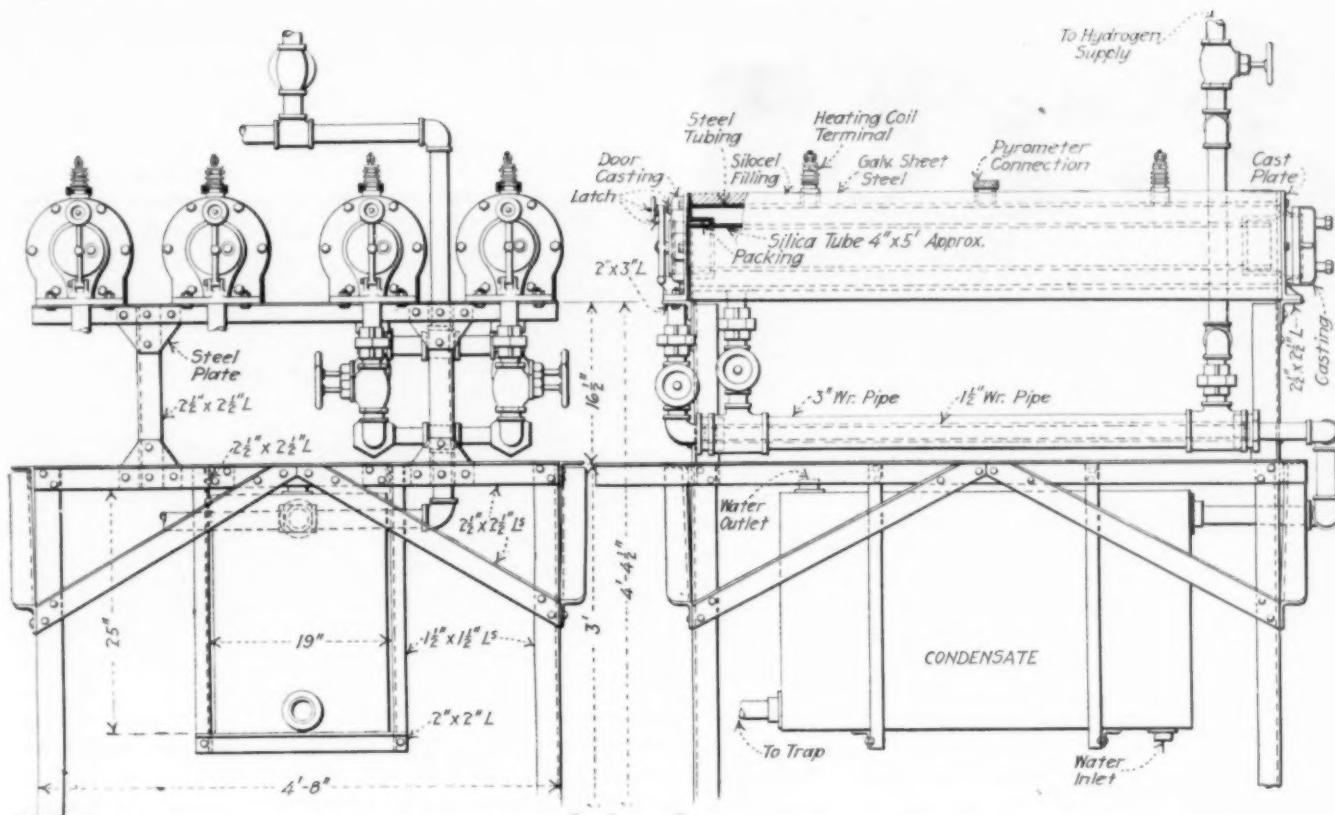


FIG. 9. NEW TYPE OF REDUCTION FURNACE

which might properly be termed cast tungsten. The bars vary in size as desired according to die used. The average bar is 1 in. square and 8 in. long.

#### SINTERING FURNACES

These bars are placed between contacts as shown in the sintering furnace, Fig. 12, where they are subjected to a current of 2750 amp. at 220 volts single phase. The temperature is maintained in an atmosphere of dry hydrogen and the body of the furnace is water cooled. The large bottle on the right contains calcium chloride for drying the hydrogen.

Fig. 11 shows the furnace closed and in operation, while Fig. 12 illustrates a bar just finished and in place in the furnace. This process causes considerable shrinkage in size, as may be noted by comparing with the unsintered bar on the table directly below the one between the contacts.

#### SWAGING AND DRAWING

The sintered bars are taken to the swaging room, where 14 specially designed furnaces are in operation. Each furnace consists essentially of a refractory tube surrounded by a jacket at a distance from the tube to form an annular space. The hydrogen is introduced into this space, permeates the walls of the refractory alumina and enters the center of the tube where the metal bar is placed. The hydrogen then passes out the opening through which the bar has been placed and burns in contact with the air.

Each furnace is heated, by a coil wrapped around the refractory tube, to a temperature of from 1100 deg. to 1500 deg. C. The fourteen furnaces consume 185 amp. at 220 volts single phase. The alumina tubes burn out in from 3 to 6 weeks, operating at 14 hr. per day.

The bars are heated and one end is drawn in an

Excelsior Needle Co. machine appearing on right of furnace (Fig. 13). The opposite end is then placed in the furnace first, heated, and the drawing operation repeated. This continues until the bar is brought down to the required size, either as bar or heavy wire. It is then ready for the market or for cutting into fine contact buttons.

#### CONTACT MANUFACTURE

The wheels for cutting tungsten are about 0.016 in. thick, 3 in. in diameter and made of an abrasive material with rubber as a binder. A cooling mixture is continually sprayed over the point of contact during the cutting operation. The small tungsten contact button is attached to the steel screw stud in an interesting manner. Buttons are placed in a jig with a thin sheet of copper on top of each button. Over this the screw studs are inverted so that the copper sheets lie at the surface of contact between tungsten and steel. The

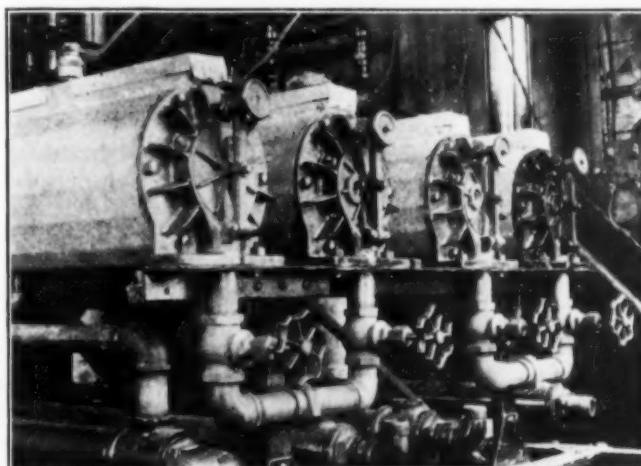


FIG. 10. FEED END OF FURNACE, WITH HYDROGEN APPARATUS IN REAR

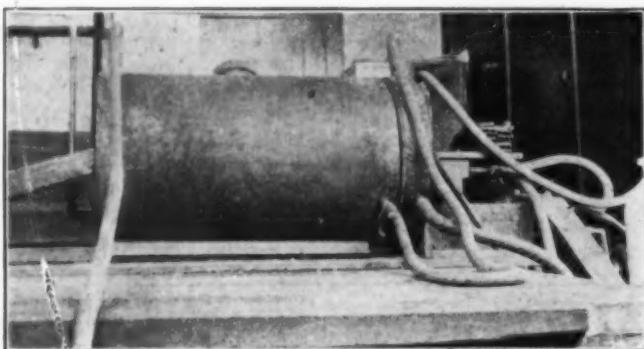


FIG. 11. SINTERING FURNACE CLOSED

whole is then placed in a hydrogen atmosphere furnace battery illustrated in Fig. 14 and of design similar to swaging furnaces.

The temperature is brought up to a point where the copper volatilizes, permeating both the steel and tungsten to a sufficient extent to braze the two firmly. This covers the entire contact with a copper plating, which is removed in a Hanson-Van Winkle deplating bath. The point is then polished on an oiled abrasive wheel and is ready for the market.

#### ROLLING SHEETS

The rolling operation is somewhat more difficult and requires expert attention. The swaged bar about  $\frac{1}{2}$  in. by  $\frac{1}{4}$  in. in section is heated in a small furnace shown in

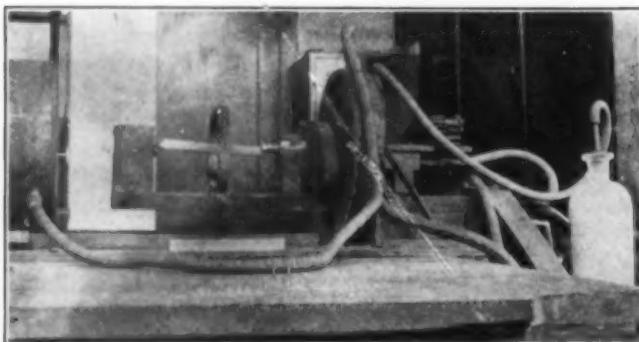


FIG. 12. SINTERING FURNACE OPEN

Fig. 14 to about 1200 deg. to 1400 deg. C. The furnace consumes 45 amp. at 220 volts single phase.

With continued heating and rolling in the preliminary rolls shown in Fig. 15 the bar is brought to a thick strip. As the strip grows thinner care must be exercised during the heat to prevent excess heat resintering the metal. The strip is then removed to finishing rolls and furnace (Fig. 16), where it is brought down to required thickness by continued heating and rolling.

It will be noted in the background of several of these illustrations that a quantity of electrical apparatus is in evidence. All the transformers, furnaces and regulators were designed and made by the Fansteel Products Co. This was necessary owing to the special nature of the work involved.

#### PROPERTIES OF PURE METALLIC TUNGSTEN

The company produces tungsten wire in round shapes from 0.080 wire up to  $\frac{1}{2}$ -in. rods and sheets for special purposes as desired. The metal is a pure wrought, ductile, fibrous substance as shown in the foregoing processes. It is rolled into thin sheets and it may be welded at yellow heat. The melting point is about 3080 deg. C. and the specific gravity 18.8.

The tensile strength in a 5-mm. diameter wire is 460,000 lb. per sq.in. and in a 1.2-mm. diameter is 580,000 lb. per sq.in. Rolled sheets have a tensile strength of 500,000 lb. per sq.in. It is not affected by air or water at temperatures below red heat.

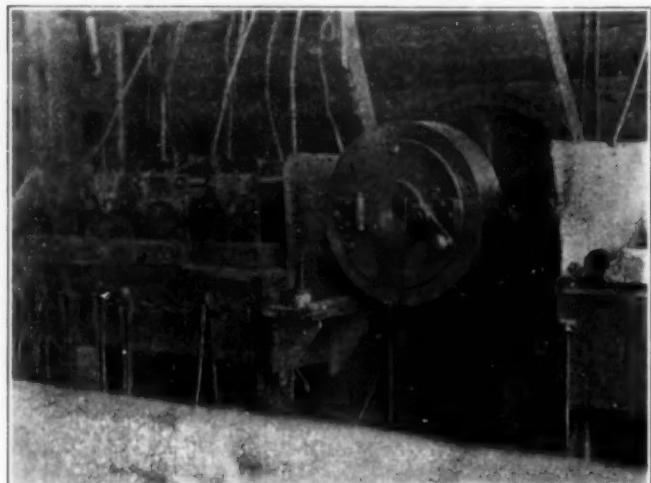


FIG. 13. SWAGING ROOM

While fused nitrates, peroxides, potassium bisulphate, alkali carbonates and caustic alkalis attack the metal, it remains unaffected by solutions of these chemicals.

#### REACTIONS WITH ACIDS

Sulphuric acid, boiling, dilute, has no effect.

Sulphuric acid, boiling, concentrated, attacks very slowly.

Hydrochloric acid, boiling, concentrated, attacks slowly, but neither strong nor dilute affect at ordinary temperatures.

Nitric acid, concentrated or dilute, has no effect.

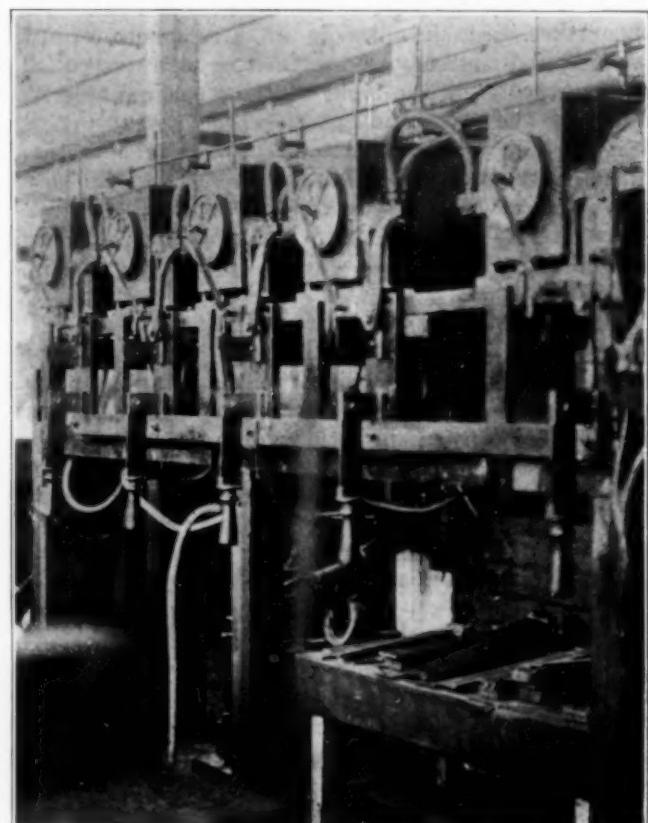


FIG. 14. BRAZING FURNACES

Hydrofluoric, concentrated or dilute, has no effect. Mixture of concentrated HCl and HF attack rapidly.

#### USES OF TUNGSTEN ASIDE FROM STEEL INDUSTRY

In the electrical industry the use of tungsten is well known, being superior to platinum for contact points on account of its hardness and having a heat conductivity equal to twice that of platinum. It is employed as a target for Röntgen Rays in electrophysical work.

Tungsten bronzes are produced by fusing with pure tin. These are resistant to ordinary acid action.

The dye industry employs tungsten for fireproofing cloth, and as a mordant for silks the salt has the added feature of serving as a weighting material.

In the ceramic industry the tungstic oxide is used for producing yellows in glass and porcelain. (A. Granger, *Compt. rend.*, 1905, pp. 140-935.)

Sodium tungstate decolorizes acetic acid.

In the chemical industry the wire and sheet, being impervious to alkali solutions and to cold and hot acids to the extent described above, should find many practical applications, such as binding cloth on filter wheels, wire gauze for filtering acids; wire mesh for supporting filter cloths; as a support for asbestos packing at Duriron connections; in utensils for nitric and hydrofluoric acids in the laboratory; heating elements in laboratory ovens; as electrodes in certain electrochemical processes; in instrument parts where subjected to fumes from the processes; and as supports for incandescent gas mantles. A thermocouple of tungsten-molybdenum gives an increase in electromotive force with the increase in temperature up to 540 deg. C. and passes through zero millivolts at 1300 deg. C.

#### NON-FERROUS ALLOYS

Many alloys useful to the chemical industry have been made, and research will prove that the field in this regard is far from exhausted. Following are some of the better known metal compounds.

Aluminum (metallic) can be hardened with tungsten. Its resistance to oxidization makes it much superior to copper. See "Tungsten, Its Uses and Value," *Mining and Sci. Press*, Dec. 17, 1904.

Partinium ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec. 3, 1904) is an alloy of aluminum and tungsten. It is used by the French in automobile construction because of its lightness and strength.

Sideraphite ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec. 3, 1904) is an alloy containing a large proportion

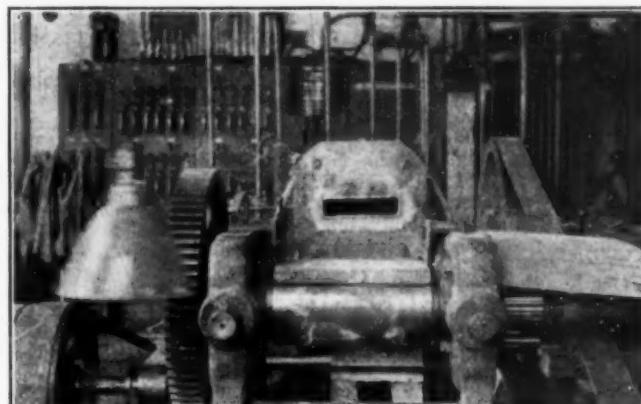


FIG. 16. ROLLING EQUIPMENT. FINISHING ROLLS

of iron, some nickel, aluminum and copper, and 4 per cent of tungsten. It resembles silver in appearance, is very ductile, malleable and not easily attacked by acids.

Minargent ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec. 3, 1904) is an alloy of copper, nickel and tungsten.

Backford, or Britannia metal, is an alloy of copper, tin and tungsten (Hadfield).

The Blackwell Company manufactures a tungsten-nickel alloy which consists of 73 to 75 per cent tungsten, 23 to 25 per cent nickel, and 2 to 2½ per cent iron, 0.75 to 1 per cent carbon, and 0.25 to 0.50 per cent silicon (Pratt).

Platinoid consists of 60 per cent copper, 25 per cent zinc, 14 per cent nickel and 1 to 2 per cent tungsten. It has a high electrical resistance, which does not decrease with heat (Hadfield).

An alloy of tungsten, aluminum and copper is used in the manufacture of propeller blades. (See "Tungsten," *Min. Res. U. S. G. S.*, 1901.)

A series of unnamed alloys has been made by L. P. Hamilton and Edgar F. Smith, *J. Am. Chem. Soc.*, March, 1901, p. 151, which consists of tungsten and copper and aluminum, tungsten-iron-titanium-carbon, and tungsten-iron-columbium-tantalum.

#### TECHNICAL CHARACTERISTICS

A table of physical and chemical constants for ductile tungsten has been prepared by C. G. Fink of the General Electric Co. as follows:

Density 19.3 to 21.4.

Tensile strength 322 to 427 kg. per sq.mm.

Young's modulus of elasticity is 42,200 kg. per sq.mm. (steel 20,000), i.e., twice that of steel.

Melting point, 3177 deg. C.

Boiling point, 3700 deg. C. (?)

Thermal conductivity 0.35 g. cal. per sq.cm. per sec. per 1 deg. C. (Pt is 0.166). Calculated.

Expansion coefficient  $4.3 \times 10^{-5}$ .

Specific heat 0.0358 (Weiss).

Resistivity (25 deg.) hard, 6.2 microhms per cu.cm.; annealed, 5.0 microhms per cu.cm.

Temperature coefficient of resistance 0.0051 (0-170 deg. C.).

Hardness 4.5 to 8.0 (Mohs scale).

Insoluble in HCl, H<sub>2</sub>SO<sub>4</sub>, HNO<sub>3</sub>, NaOH, KOH (aqueous), K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + H<sub>2</sub>SO<sub>4</sub>.

Soluble in mixtures of HF and HNO<sub>3</sub> and in fused nitrates, nitrites and peroxides.

Ductile tungsten and molybdenum are available in quantities for commercial consumption; the purity is such as to give metals with properties greatly needed by the chemical and electrochemical markets; new uses are being developed by research; and it would therefore appear that the increase in consumption must of necessity continue.

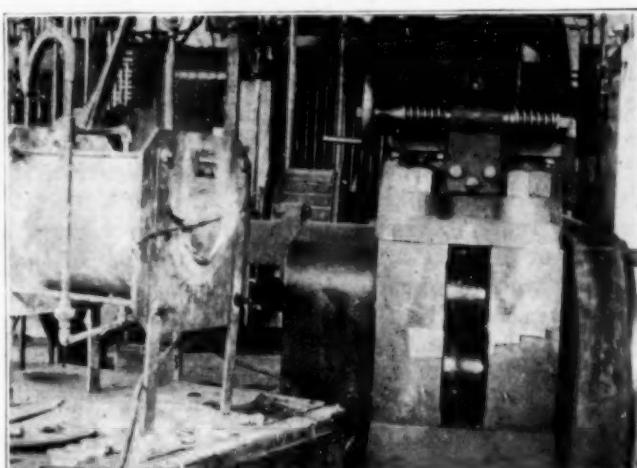


FIG. 15. ROLLING EQUIPMENT. PRELIMINARY ROLLS

We wish to acknowledge the courtesy of the Fansteel Products Co. in furnishing facilities and information for the preparation of this article.

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Other references as given in the text.

### Care of the Lumber Pile in Chemical Plants\*

THE chemical plants in this country are in a continual state of development, which means that there is always a supply of lumber on hand for repairs and expansion of various projects. As in other lines of industry, this material is usually handled carelessly, whereby the expenditure of a small amount of time and money the companies might save considerable sums each year.

One of the simple methods which may be used is the coating of the ends of timber, logs, etc., to prevent splitting and checking, which occurs especially in dry climates, due to the fact that timber dries much more rapidly from the ends than from exposure to the atmosphere on the sides. The rule for end coating in simple terms is that the harder and greener the wood, the more effective must be the coating. Paint is convenient to handle, but is of low effectiveness. White lead is convenient to handle, and is of medium effectiveness. Lorac, a commercial compound, is convenient to handle and also of considerable effectiveness, but the best application is rosin-lampblack, which is inconvenient to handle, but is of high effectiveness.

Rosin-lampblack is made according to the following formula:

Clear grade rosin.....	60 parts by weight
Lampblack .....	1 part by weight

The mixture is prepared by melting the rosin but not allowing it to boil or froth, and when in a thoroughly molten condition the lampblack is thoroughly stirred in.

This coating is applied where feasible by dipping the ends of the sticks in the molten mixture to a distance of about one-half inch, which when hardening gives a smooth, shiny coating free from bubbles and about an eighth of an inch thick over the ends. Where large timbers are to be coated the mixture may be applied with a brush or paddle.

If the stock is to be subjected to rough handling which might cause the coating to chip when cool, linseed oil may be added in the proportion of 1 to 15 by weight. This, however, will have a tendency to make the coating excessively soft at temperatures which are higher than 130 deg. F.

#### STORAGE

Many serious losses from decay in wooden structures are caused by the fact that the timbers used were infected with wood-destroying fungi while in storage. These losses may be greatly reduced by keeping the storage yard in a sanitary condition.

Strong efforts should be made to store the product on well-drained ground removed from possible danger of floods, high tides and standing water. All rotting debris scattered about yards should be collected and burned, no matter whether it be decayed formations and timbers or

stored lumber which has become infected. In the case of yards already filled in to considerable depths with sawdust and other woody debris the situation can be improved by heavy surfacing with soil, slag or similar material. Weeds should be cut away from the piles to allow good ventilation.

Solid foundations should never be used for supporting timbers. In damp climates the stock should not be piled less than 18 to 20 inches from the ground. Wood blocking used in direct contact with the wet ground should be protected by the application of creosote or other antiseptic oils or else replaced by concrete, brick or other durable materials. Treated skid timbers would be highly advantageous.

Foundations should be built so that the piles will slope approximately one inch to every foot of length. In most regions lumber should not be close piled in the open, but should be set with crossers at least one inch thick. Lateral spacing is also very desirable. Roofing or cover boards should be placed over the piles and extend for several inches in front and back.

Instead of throwing the crossers about on the ground to become infected with decay, they should be handled carefully, and when not in use piled on sound foundations and kept as dry as possible. If pine saturated with resin or the hard wood of such durable species as white oak or red gum be employed, the danger of possible infection will be greatly decreased.

Where lumber is stored in sheds the necessity of piling higher from the ground is very apparent in many cases. The same remedies apply here as for pile foundations in the open. The sheds should be tightly roofed and the siding should not be run down below the bottom of the foundation sill. Free air circulation is very necessary and only thoroughly dry stock should be stored in close piles under cover.

Should fungous outbreak occur in the storage sheds, the infected foundation timbers should all be torn out and be replaced with wood soaked in an antiseptic solution, or by concrete or brick. In all cases the new foundation should be so constructed as to keep the lumber well off the ground and the soil and timber immediately adjoining the infected areas should be sprayed or painted with an antiseptic solution of water, soluble salt, like sodium chloride, mercury chloride, zinc chloride, or copper sulphate.

### New Process for Extracting Wool Grease

A company has been formed in Melbourne for the purpose of exploiting a new process for extracting grease (adeps lanæ, the base of lanolin) from wool, and for the manufacture of special neutral wool-scouring and other soaps. The principal supply of lanolin in pre-war times, it is stated, was drawn from Belgium and Germany. The method of treatment was a trade secret, and no public description is in existence, but it is known that sulphuric acid was used in the final process of refining. In the new Australian process no sulphuric or other acid is used, and the product of the process is wholly animal and pure. A small plant has already been erected and the process tested sufficiently to prove that by it adeps lanæ can be produced in commercial quantities at a very low cost.

(Persons interested can obtain the address of the inventor of the process from the Bureau of Foreign and Domestic Commerce, or its district or co-operative offices, by referring to file No. 40859.)

\*Abstracts from Forest Products Laboratory Technical Notes.

## Filtration and Filters\*

BY HENRY B. FABER

THE importance of filtration in industrial work has during the past three or four years been emphasized particularly in those chemical and industrial lines dealing directly and indirectly with products necessary for war. As we are approaching an era of expansion in all industries, and particularly so in the chemical industry, research and development will call for new methods of manufacture. A note of caution may properly be sounded at this time. Too often the technical man, carried up to too great an altitude by his chemical research, flies too high and neglects to give proper emphasis to the simpler operations, such as filtration, which act as the Scylla and Charybdis to wreck the chemical mariner.

From experience in the handling of a large number and variety of filtering problems, I am inclined to classify them in two major groups.

First, those problems in which the slurries contain suspensions of a colloidal nature. These can hardly be dealt with except by highly specialized forms of apparatus and might even be regarded as a class not applicable to simple filtration. This group will, therefore, be passed over.

Second, those problems in which the solid suspensions may be separated from the liquid by the simple expedient of a filter medium. This latter group may be divided as follows:

Class A, which embraces those slurries in which the suspensions are fine, but not of a colloidal character. This group includes those slurries which contain slow filtering suspensions in large or small bulk, and those slurries which by reason of a relatively small amount of suspended matter require merely clarification.

Class B embraces those slurries containing relatively free filtering suspensions, which permit the liquid content to be separated readily from the solids, where the solid content is of considerable bulk, crystalline or definite in its form.

Class C embraces those slurries which are principally mother liquors, containing relatively large crystals, in which the liquid content can be drained readily, the crystals washed easily, the principal problem being the automatic and easy handling of the solids.

The filtration engineer has designed various types of filtering equipment to be applied to these various groups. A description of their types and their limitations as applied to the various groups will, I believe, be of interest, together with a short sketch of the development of these various types.

### Filters for Class A Problems

In class A of group II, in which the suspensions are fine and the slurries slow in filtering, the engineer has two problems confronting him—the problem of large area of filter surface and that of keeping the filter surface clean.

### THE FILTER PRESS

The filter press is probably the best known type of filter equipment in use. The press consists of a series of shallow frames separated one from another by plates and nested together, forming a series of shallow chambers. Against the plates, which are channelled

or scored with shallow galleries, are placed filter cloths, which act as the filtering medium. The slurry to be filtered is pumped into the chambers, the liquid forcing its way through the medium and making its exit by means of the galleries or grooves, leaving the solids deposited upon the medium and gradually filling up the chambers.

### OPEN TANK LEAF FILTER

It remained to one George Moore, a metallurgist, to invent a process of filtration in the mining field which has had world-wide acceptance and renown. This process employed the use of filter leaves, operating in an open tank. These leaves were frames of pipe, usually rectangular in shape, over which was sewn filter cloth completely incasing the frames and forming a hollow shallow chamber with ribs spaced equidistant across the face of the leaf for the purpose of preventing the two faces of the cloth from touching. The pipe constituting the lower edge of the frame was perforated. When the leaf was submerged in the slurry to be filtered and suction applied, this suction was translated throughout the entire space within the leaf, causing the liquid to pass rapidly through the cloth, leaving deposited upon the outside surface the solids, in the form of an adhering cake. Many of these leaves were attached to a common header and in this form was called a "basket." The simplicity of this construction permitted the operator to throw into use very large areas of filtering surface at a relatively low cost.

### SELF-DUMPING FILTER

At the time of this invention, George Moore anticipated that many problems would be encountered where a greater force than that exerted by a vacuum pull would be necessary to make the separations of solids from liquids. His original patents also called for the incasing of these filter leaves in some simple form of container for use by either suction or pressure. The self-dumping filters, so called, in which the container may be parted from the leaves, shortly made its appearance on the field, and met with wide acceptance in both the mining and industrial world. These filters, in which the basket of filter leaves is completely incased by a container permitting either suction or pressure to be applied to force the liquid through the medium, have a wide application in the many filtering problems of to-day.

### COMPARISON OF THE VARIOUS TYPES OF FILTER

To sum up the virtues of these various types, the press, by reason of the fact that the filter cloths can be replaced readily, at a relatively low cost, protects the operator from serious curtailment in his filtering operations by reason of accidental damage to the cloths.

The open tank leaf filter has the advantage of large area of filtering surface and extremely low initial cost.

The self-dumping types of filters, by reason of the fact that they can use pressure as well as suction, have a wider latitude of use, but the same argument applies to them as applies to the open tank leaf type in that time is lost in re-covering the leaves, and repair and renewal are costly.

### Filters for Class B Problems

In reference to the handling of problems in class B, viz.: those slurries which are relatively free filtering and build a substantial firm filter cake quickly, the rotary filter is the most desirable type to use.

\*Extract from address before the Fifth National Exposition of Chemical Industries, Chicago, Sept. 25, 1919.

The rotary filter made its first appearance in Belgium about 50 years ago or thereabouts, and consisted of a headed barrel rotating about its long axis. The face of the drum was perforated and a filtering medium was stretched around, completely encircling the drum, and held in place by winding cords. This machine was used for the filtration of salts and proved very effective. A gooseneck entered through the head of the drum, dipping down to within an inch of the bottom, and was the means through which suction was applied to the interior of the drum. The drum rotated in a shallow container, dipping into the slurry through an arc of about 40 deg. Later this type of machine was built of sturdy metal construction. The perforated surface was replaced by bars of iron, forming a grating so that the drum had the appearance of a heroic-sized squirrel cage. In all cases, a gooseneck dipping within the drum downward to within a few inches of the bottom served as an exhaust and also to carry the liquid from the inside of the drum.

When rotating, the filter cake, which adhered to the surface of the drum, passed upward and over beyond the zenith, and was removed by means of a scraper.

It remained to the same George Moore who invented the Moore process of filtration to invent a multiple compartment or revolvable filter, which is the rotary filter of today. This filter, instead of being of the squirrel-cage type with a gooseneck outlet, has the peripheral surface of the drum composed of a number of shallow hollow compartments, over which is stretched the filtering medium. Each of these hollow compartments has its own separate pipe line connected to a valve hub by means of which suction or pressure may be applied at will, through any desired arc.

These machines have had wide usage in the mining field for the handling of concentrates and are extensively used in the industrial chemical field, where automatic and continuous filtration is rapidly replacing the batch or intermittent method.

#### **Filters for Class C Problems**

In handling slurries of the character mentioned as class C, viz.: crystals from mother liquid or coarse granular suspensions, the centrifugal or draining boards have been widely used.

#### **ROTARY HOPPER DEWATERER**

The rotary filter has failed in many cases by reason of the fact that the solids will form too heavy a cake and will not adhere firmly enough to prevent the cake breaking away from the drum and thickening in the container. The rotary hopper dewaterer is a type of filter machine built especially for this class of work, and consists of a series of elongated hoppers arranged radially about a central axis, each hopper having a filter bed, below which a pipe line connects with the central valve hub, similar in design to that used in the construction of the rotary filter. As the filter beds are set quite a distance below the rim of the hoppers, they form in reality a series of filter trays, revolving slowly about a central axis. The slurry is fed into these trays at a point about 30 deg. from the zenith and dewatered by means of suction as they rotate through an arc of about 40 deg. Suction is then automatically cut off and the product discharged either by gravity or by a puff of air, making the operation continuous and automatic.

#### **Practical Suggestions for the Engineer**

##### **SETTLING SHOULD PRECEDE FILTERING**

In a great number of the ordinary filtering problems, settling should precede the operation of filtering, or the slurries should be thickened by some means until the amount of suspension has reached the maximum permissible for easy handling. Suspensions will settle at a relatively uniform rate of fall until they thicken to such an extent that they begin to clump. It is usual to consider the rate of settling as uniform until the particles approach one another by a distance less than five times their diameter, at which point the settling rate begins to slow down very rapidly. A simple test that is often made in the laboratory is to permit the slurry to settle freely and plot a curve, showing the widening of the clear supernatant liquor. A point will be noticed in the large majority of problems where the curve shows a marked slowing down of the rate. It is at this point that we find it desirable to complete the separation by filtration. Too often the engineer attempts either to settle completely his slurries or to filter completely his slurries, where a combination of settling and filtering will give a much more efficient operation. This is a general statement, but one which will bear emphasis.

#### **EXPERIMENTAL FILTER FOR CLASSIFYING FILTRATION PROBLEMS**

The class in which a particular filtration problem belongs may be determined easily by using a small experimental filter leaf constructed as follows:

Bend a small piece of  $\frac{1}{2}$ -in. brass pipe in the form of a square paddle with sides approximately  $3\frac{1}{4}$ -in., perforate the lower side and stitch over the frame either unbleached muslin, No. 10 duck or other suitable filtering medium. Strips of wood about the thickness of a lead pencil are inserted between the faces of the cloth in order to prevent collapsing. The filter leaf is now complete. By vacuum rubber pipe 2 or 3 ft. in length, the leaf may be attached to a graduated Woulff bottle, which in turn should be connected up to the suction line. Introduce into a battery jar or large beaker the slurry and submerge the filter leaf. When the suction is turned on, the liquid will pass through the leaf into the Woulff bottle, leaving deposited upon the face of the leaf the solids. Note the time, quantity and character of the liquid constituting the filtrate and the thickness and character of the filter cake produced for the given period of time. The filter leaf with the adhering cake when withdrawn from the slurry may be introduced into a receiver containing wash water, and the wash water drawn through in the same manner as the filtrate. The amount of water necessary to wash the cake can be readily measured, the period of time necessary for washing obtained, and the dryness of the cake determined by allowing the filter leaf with adhering cake after being withdrawn from the wash water to be held suspended in the air until the occluded liquid has been sucked out of its pores. A filter leaf of the above-mentioned size will have approximately one-sixth of a square foot of active filtering surface, and when a ratio is struck between the volume of filtrate or weight of cake to one-sixth of a square foot for the particular period of time employed, the operator can readily calculate the number of square feet of active filtering surface he will need for an installation capable of handling a given quantity of liquid or solid. He will

also be able to determine the amount of wash water, the purity of his cake and moisture content of the latter, which will closely approximate the results he will obtain on a commercial installation.

#### DEDUCTIONS FROM EXPERIMENTAL TESTS

From these tests a few general deductions can be made. If it takes a longer time than ten minutes to form a filter cake of at least  $\frac{1}{2}$  in. in thickness, in all probabilities the problem falls into class A, in which are included the filter press, open tank leaf filter and the self-dumping filters. If a firm cake of from  $\frac{1}{2}$  in. to upwards of 2 or 3 in. in thickness can be formed in less than ten minutes, and if the cake frees itself readily from the filter leaf, a rotary filter will very likely handle the problem. In determining the size of the rotary filter by this simple test required for any problem, it must be borne in mind that any point on the peripheral surface on the filter drum will require from one to ten minutes to pass through the full 360 deg. according as the machine makes one r.p.m. or one-tenth r.p.m. Consequently, as frequently less than one-half of the surface of the drum is submerged continuously in the slurry through which it rotates, the requirements for filter surface for continuous operation must be multiplied by approximately two, as less than one-half of the drum is active for cake building. If in making the tests a cake builds so rapidly on the filter leaf and the product is of such a granular nature that in attempting to withdraw the leaf from the slurry the cake will not adhere, but slough off, the centrifugal or the rotary hopper dewaterer will most likely be the type of machine for use.

#### SUGGESTIONS ON WASHING

Often it is as important to wash the solids as it is to filter them, and a few suggestions along this line may be in order. Irrespective of the type of filter used, the one important factor to provide against is the channeling of the filter cake. In the filter press as well as the self-dumping type it is difficult to provide against a classification of the solids, as the heavier particles will often settle away from the lighter, forming areas of less resistance to the passage of the filtrate. This classification is not met with to any noticeable extent in the open tank leaf type of filter, as the slurries may be kept in constant and thorough agitation during the process of filtration, thus insuring a homogeneous slurry. Consequently, it has been my experience that washing on the open tank leaf type of filter can be accomplished with less wash water and a more thoroughly cleansed product obtained than by either the press or self-dumping type. It seems to be a prevailing custom among engineers to determine the degree of wash that a filter cake has been subjected to by merely testing the wash water coming from the filter. Let me suggest to those who are operating different types of filters, to sample the filter cake itself. Without a doubt, in many instances surprisingly curious results will be obtained. In sampling I do not mean the ordinary grab sample, but a number of samples taken from different parts in the chamber or on the filter leaf. In many cases it will be found that the most astonishing results are due to channeling.

Another important point on the subject of washing is that we do not get the advantages of diffusion to the extent desired by passing our wash water through

the cake, and it has been my practice to recommend wherever it is possible where extreme degrees of washing are required with a minimum amount of wash water to discharge the cake after the mother liquor has been replaced to a reasonable extent by wash water, and to churn up or cream the product, thus getting the advantages of diffusion and refilter. I wish to emphasize this method of washing, particularly in the case of the rotary filter, where the period of washing is relatively short, and where much is left to be desired where filtering and washing and automatic discharge are accomplished in one revolution of the filter drum. Most gratifying and surprising results have been obtained on difficult problems of washing where only a sufficient amount of wash water is sprayed upon the cake to replace the mother liquor held by the cake volume for volume, and the cake discharged into some form of agitating tank in which it is creamed up with wash water in sufficient amount to permit of easy handling of the slurry and refiltered.

One other important point before closing the subject of washing is, in dealing with free alkalis, the passage of steam through the cake prior to washing with water will often show very beneficial results.

#### IMPORTANCE OF AMPLE PUMP CAPACITY

Why it is that the engineer after recommending the purchase of expensive installation will suddenly take it into his head to economize on the size of the pump, and particularly the size of the pump lines in connection with vacuum filtration, has always been a mystery to me, and yet it is a fact. Allow me to emphasize the need of ample pump capacity. In the filtration of bicarbonate of soda the pump displacement should be from 10 to 15 cu.ft. per minute of free air per sq.ft. of active filtering surface unsubmerged. This amount of free air per sq.ft. decreases rapidly as the porosity of the cake decreases. Carbonate of lime or caustic lime mud from the ordinary soda-lime process requires only from 3 to 5 cu.ft. per unit square area of filtering surface. Another point that the engineer seems to neglect to take into consideration is that short suction lines are preferable to long lines. In one instance I have in mind a 500-ft. suction line, which, although of adequate diameter, failed completely to function, due to its extreme length.

#### CONCLUSION

In concluding, allow me to offer a few suggestions to the manufacturers and chemists who have filtering problems to solve.

Filtration is too important a factor in the operation of any plant, where the separation of solids from liquids is a step in the operations, to neglect careful, faithful research on the most practical means of obtaining the separation. These problems cannot be brushed hastily aside or decided hurriedly, but should entail the same thoroughness in research that any technical chemical operation deserves. One of the most important points to emphasize is that in many cases filtration will not be as difficult an operation if more care and attention are given to the form in which the solids appear at the time that filtration is to be attempted. In other words, the chemical reactions should have run their course and the suspensions should have been allowed to form themselves in a physical condition as far as practical, giving the best separation possible in consideration of their nature and crystalline structure.

## Recovery of the Nitrogen Contained In Oil Shales

BY LOUIS SIMPSON

THE question of the economic retorting of oil-yielding shales will be governed by the results of the retort controversy. Whether the oil shale operators of this continent decide to use the "dual purpose" retort of Scotland, with its elaborate attempt to secure as large a yield of nitrogen as may be possible, or whether they will elect to use a "single purpose" retort, which will give them the largest possible yield of high-grade oil, with a small yield of recovered nitrogen, remains to be seen.

It is a pity that the governments, which are so greatly interested, have not as yet seen their way to aid the operators to solve this question. The proof can be gained only at the risk of a considerable expenditure, much of which would be common to all the tests that would have to be made, hence much duplication of expense would be avoided, were any one or more of the governments interested to arrange for comparative trial runs of the several classes of retorts.

### ECONOMIC COMPARISON OF THE "DUAL PURPOSE" AND "SINGLE PURPOSE" RETORTS

The first question that has to be decided is whether the "dual purpose" retort or the "single purpose" retort is the more economic when operating under the special conditions existing in different parts of the North American continent.

The "dual purpose" retort has been perfected to reduce the oil contained in the shale and at the same time to recover to the greatest possible extent the nitrogen contents of the shale. Owing to certain peculiar conditions present in Scotland years ago, this retort was perfected so that the nitrogen contents might be recovered and were recovered even at the expense of the oil contents. The "single purpose" retort is designed so as to make the utmost recovery of the oil contents and so to make such recovery that the risk of cracking the reduced oil is lessened. The "double purpose" retort with its necessary accessories is very expensive to build, while the best examples of "single purpose" retorts can be constructed for very much less money. In Scotland, years ago, when the selling price of oil was very low, when gasoline was almost unsalable and when sulphate of ammonia was selling at prices very much higher than pre-war prices, the operators solved the question, so far as they themselves, then, were concerned, by perfecting the "dual purpose" retort. The operations of this retort in Scotland have certainly proved to be very profitable, but it was the local conditions that made the operations of the retort profitable and given other and widely different local and unfavorable conditions, the results would have been very different. The local conditions now existing on the North American continent are nearly, in every item, the opposite to those existing in Scotland when the "dual purpose" retort was perfected, and on this account it is not safe to accept the results obtained in Scotland from the operations of the "dual purpose" retort as the results likely to be obtained by the use of that retort when operated on this continent.

To make this point clear, the conditions that existed in Scotland and the conditions that exist at many, probably at the majority of locations on this continent,

are given in Table I, placed side by side for comparison. It is, however, admitted that locations are to be found where the conditions as stated are not present.

TABLE I—COMPARISON OF CONDITIONS IN SCOTLAND AND IN NORTH AMERICA

	As they existed in Scotland	As existing in North America
Shale, quality	Relatively low in oil contents, but high in nitrogen contents	Relatively high in oil contents, but usually low in nitrogen contents
Oil contents	Sale price low	Sale price much higher
Sulphate	Sale price very high	Pre-war sale price very low
Sulphuric acid	Very low in price delivered	Generally high in price delivered
Bagging	Very low in price delivered	Generally high in price delivered
Machinery and repairs	Low in price delivered	High in price delivered
Wages	Low	Before the war double the scale; now probably four times the old rate
Coal	Low in price delivered	Generally dearer, but in this cost great variations will be found
Market for sulphate	World-wide and therefore in constant demand	Local and therefore seasonal, entailing carrying large stocks
Money	Easily obtainable at low interest	Much dearer

The probable future demand for sulphate of ammonia and its market price are quite obscure. It is known that the manufacture of the products of nitrogen has been immensely increased during the war, while the present consumption is probably not larger than it was before the war, if as large. It is known that much of this increase is from by-product coke ovens, and therefore this source of supply will be persistent in the future, whatever level prices reach. It is known that the remainder of the increase is from processes that obtain the nitrogen from the air, and although it is not certain, it is supposed that these plants will continue to operate.

If sulphate of ammonia and other products of nitrogen are necessary for the welfare of those interested in agriculture, it is not likely that these works, indirectly, in part, paid for by those so interested, will be allowed to lie idle, so that the coke barons and others may charge a high price for a by-product. It is therefore probable that prices will fall to their pre-war level and perhaps lower. Notwithstanding, and in spite of these facts, writers and speakers still persist in claiming that the successful establishment of the oil shale industry depends upon the continued extreme recovery of the nitrogen contained in the shale.

This article is written with the hope of showing that this contention is wrong. Only under special conditions, not often present on this continent, will the utmost possible recovery of the nitrogen in the oil shale become of financial and economic importance and in such rare cases it is possible to add to the approved "single purpose" retort special machinery, especially designed, operated independently from the retort, which will recover the nitrogen as well as if not better than can today be done in the nitrogen recovery section of the "dual purpose" retort.

The axiom still holds good, that by-products should not be manufactured unless the profits accruing upon the money invested in the works and machinery and the working capital necessary for the recovery are equal to or exceed those which would have accrued had the same amount of money been expended in enlarging the output of the original business.

Before a judgment can be arrived at it is necessary that the cost of producing sulphate of ammonia from

nitrogen recovered in the "dual purpose" retort be correctly ascertained.

The late Dr. R. W. Ells, in his report published in 1909 by the Canadian Government on the "Oil Shales of New Brunswick and Nova Scotia," has unintentionally been the cause of much misunderstanding on this point.

On page 35 of his report the cost of the "manufacture of sulphate" is given as 46c. per ton shale. It is not stated to what yield of sulphate per ton shale this figure applies, and as the cost in certain items varies with the yield of sulphate per ton shale, the yield becomes a matter of considerable importance. As, however, Dr. Ells on the previous page had mentioned a shale yielding 77 lb. sulphate per ton, it is presumable that the 46c. was given as the cost of manufacturing 77 lb. of sulphate per ton shale. This cost totals \$11.95 per ton of 2000 lb. of sulphate.

Authorities in England have given the cost of manufacturing sulphate from ammonia liquor as being before the war as stated in Table II.

TABLE II—COST TO MANUFACTURE SULPHATE FROM AMMONIA LIQUOR

18 cwt. sulphuric acid at 60 deg. B. at \$13.33 per ton	\$12.00
3 cwt. lime . . . . . at \$ 2.40 per ton	0.36
Coke . . . . .	1.10
Bags (containers) . . . . .	0.86
Repairs, etc. . . . .	1.10
Labor . . . . .	3.00
Cost in England before the war . . . . .	\$18.42

This cost is considerably higher than that given by Dr. Ells. Dr. Ells gives no details, so it is not possible to explain this wide (50 per cent) difference, which, however, probably consists in the increased cost of acid (the Scotch purchase their acid at a very low cost, delivered), bags and fuel. Perhaps also Dr. Ells forgot to make any allowance for repairs. In neither estimate are included costs of interest, depreciation or management.

Both Dr. Ells' cost and the English cost were costs before the war, and the cost in both countries would have to be considerably increased to represent today's costs, which may safely be taken to exceed \$25 per ton sulphate.

But the \$25 cost represents only the cost of manufacture from ammonia liquor to the sulphate. Besides this cost, the cost of recovering the nitrogen (in the form of ammonia) from the shale must be ascertained.

At this point it may be wise to point out that the objective of the investor of money in the oil shale industry is the winning of dollars upon the dollars invested. It is from this viewpoint that the rival retort processes have to be judged. Therefore, to the costs already discussed must be added the extra overhead charges of interest, depreciation and repairs chargeable, owing to the extra cost of the "dual purpose" retort and of its larger exhausters, condensers, pipes and steam boilers, also the extra cost of fuel and water and the extra interest upon working capital required to carry a stock of bags and of sulphate, waiting for shipment to fill the season's orders.

As the making of money is the objective, it is quite legitimate to charge up against the cost of manufacture the interest upon the capital expended, at the rate the money so expended would have earned had it been expended in the recovery of oil from an increased

quantity of shale instead of in the recovery of nitrogen and of the manufacture of this nitrogen, so recovered, into sulphate. When this is done, if the total so arrived at is less than the selling price of the sulphate, the manufacture of this sulphate may be considered, but if the total be more, then, and in that case, the manufacture of the sulphate should be avoided.

To show at a glance how local conditions affect the result, Table III has been compiled. The basis upon which this table has been calculated is as follows:

An installation to treat 1000 tons of shale per day of 24 hours, 365 days per year. (1) "Dual purpose" retort, plant with sulphate manufacturing costing \$1,200,000. (2) "Single purpose" retort plant without sulphate manufacturing costing \$300,000. Depreciation allowed at 15 per cent per annum, interest calculated at different rates from 50 per cent down to 15 per cent (it is believed that some deposits will make it possible for those operating to earn the larger figures and it is not thought that many will expect to earn less than 15 per cent). The returns of sulphate per ton shale are taken from 70 lb. down to 30 lb. By referring to this table and by adding the figure found, where the interest and the per cent of sulphate meet, to the \$25 before mentioned, a total will be reached that will indicate nearly the actual cost of the sulphate, when made by the use of the "dual purpose" retort.

TABLE III—COST OF SULPHATE (Overhead and Profit only)

	70 lb. per ton shale	60 lb. per ton shale	50 lb. per ton shale	40 lb. per ton shale	30 lb. per ton shale
50%	\$45.79	\$53.42	\$64.10	\$80.13	\$106.84
40%	38.73	45.20	54.24	67.80	90.40
30%	31.70	36.98	44.37	55.47	73.96
25%	28.17	32.87	39.44	49.30	65.74
20%	24.65	28.76	34.51	43.14	57.52
15%	21.13	24.66	29.59	36.99	49.32

It is believed that the \$25 cost per ton for manufacture, which has to be added to the above, is far too low a present estimate; but using that cost as a basis, the following results are obtained:

Where oil discovery alone would yield only 15 per cent profit on the capital employed and with shale yielding 30 lb. sulphate per ton the cost would be \$74.32 per ton; where the oil yields 50 per cent profit, the cost of sulphate would be \$131.84 per ton. With 50 lb. shale the low cost would be \$54.59 and the high cost \$89.10. Seventy lb. sulphate per ton shale is an exceptional return. But to the above total a further charge may have to be added in cases where the capital at command is not sufficient to warrant the erection of a 1000-ton plant using the "dual purpose" retort. In many cases where only 250 tons per day are mined and assembled instead of 1000 tons, it may be assumed that the cost of mining, assembling, and of management will be increased by 25c. per ton of shale. This 25c. per ton shale when retorting shale that yields 30 lb. sulphate of ammonia increases the cost per ton sulphate by no less than \$15.

Mention has been made of a possible arrangement by which the nitrogen left in the spent shale can be conveniently recovered. There is no doubt that were the spent shale from a 1000-ton shale unit treated in a revolving horizontal kiln (especially in such cases where the shale contains considerable fixed carbon), it would be possible to recover not only a very high percentage of the nitrogen, but also, if found desirable, the potash contents.

## CONCLUSIONS

1. The "dual purpose" retort is only of interest when exceptional conditions are present, conditions that are not often met with on the North American continent.
2. The future of the oil shale industry is largely dependent upon the construction of a "single purpose" retort that can be erected at a low cost and which will recover the maximum quantity of oil.
3. It is possible to arrange for a machine which operates independently from the "single purpose" retort, which will recover the contents of nitrogen even more completely than can be done in the nitrogen recovery end of a "dual purpose" retort.
4. Some nitrogen, if desired, can be recovered from the "single purpose" retort, but such recovery is not advisable unless sulphuric acid is obtainable at a low price delivered or unless there be a good local market for the sulphate.

## C. P. Zinc for Fixation of the Temperature Scale

By A. O. ASHMAN

ZINC is probably the most important substance (aside from water) used in the fixation of the temperature scale, its value in this connection being due chiefly to its melting or freezing point, the boiling point being seldom used. The characteristics of this melting point may be stated briefly as follows:

(1) The melting point (419.4 deg.  $\pm$  0.1 deg.) as determined by the cooling curve method is extremely sharp and easy to obtain.

(2) It has practically no undercooling effect.

(3) Zinc does not oxidize perceptibly at this temperature, and moreover the oxide is not soluble in the metal, so that the melting point is not affected by oxidation.

(4) Zinc is not easily contaminated by containers commonly used in making melting point determinations, and with due care will last indefinitely.

(5) The position of the melting point is about at the upper limit of usefulness of the copper-constantan couple, and at about the lower limit of the platinum-rhodium couple, the two most commonly used laboratory couples.

### SOURCE OF SUPPLY

Prior to the war, zinc sufficiently reliable for this work could be obtained from only one source, which in keeping with existing custom was a German concern. Kahlbaum zinc, as well as other metals, was recognized as the standard for this use. Since the opening of the war C.P. zinc has been prepared in this country in a much higher state of purity. This metal is now on the market, and can be obtained in stick form in any desired quantity. It has a constant purity and melting point.

### PREPARATION

The method of preparing C.P. zinc has been published in detail by the Bureau of Standards,<sup>1</sup> and is briefly as follows: The pure zinc is prepared by redistillation of Horsehead spelter. This is carried out in a coal-fired muffle furnace.

Each muffle is filled with approximately 250 lb. of

spelter and heated until volatilization begins. The temperature is very carefully regulated by means of a recording pyrometer, as the lead content is dependent almost entirely on the proper temperature, the process being a fractional distillation.

As the zinc is distilled off the lead content of the residue is increased proportionally, and at a certain concentration is carried over with the zinc. When this is the case the charge is drawn and a new one introduced. The burden in the muffles is kept constant by adding spelter equivalent to the weight removed by each draw.

The zinc so prepared is then cast into sticks  $\frac{1}{4}$ -in. diameter by 8-in. long, this shape being desirable on account of the ease of breaking without the use of contaminating tools.

The distinguishing characteristics of pure zinc are its extreme softness and beautiful crystallization.

### PURITY AND EFFECT ON MELTING POINT

Table I, copied from Bureau of Standards Circular No. 66, shows the chemical analysis for Kahlbaum zinc, and zinc produced by the New Jersey Zinc Co.

TABLE I—ANALYSIS OF ZINC SAMPLES

Element Sought	New Jersey Zinc Co.'s Redistilled Horsehead Spelter	C. A. F. Kahlbaum Zinc
Iron.....	0.005	0.001
Lead.....	0.0004	0.021
Cadmium.....	0.0018	0.021
Arsenic.....	Trace	Trace
Antimony.....	Not detected	Not detected
Tin.....	Not detected	Not detected
Sulphur.....	Trace	Trace
Zinc by difference.....	99.993	99.957
Total impurities.....	0.007	0.043
Melting point.....	419.44°C.	419.30°C.

Wardner and Burgess<sup>2</sup> have found differences of 2.5 deg. C. in the melting points of zinc obtained from different sources. Unfortunately, however, corresponding chemical analyses are not given.

Kreisinger and Barkley<sup>3</sup> point out that metals obtained for this work from chemical supply houses melt at from 2 to 5 deg. lower than corresponding Kahlbaum pure metals.

It is seen from the table that the difference in melting point is 0.14 deg. C. Assuming this is a function only of the impurities present, a difference of less than 0.03 per cent impurities in the zinc will change the melting point by 0.1 deg. C.

In view of the extreme purity of the New Jersey Zinc Co.'s zinc and constancy of the product, we believe that it would be well worth while for the Bureau of Standards to re-determine the freezing point, thereby fixing the temperature scale with an accuracy of at least  $\pm$  0.05 deg. and probably 0.01 deg. at that point instead of  $\pm$  0.1, as at present.

The methods used in making primary calibrations are well known<sup>4</sup> and will not be given here. It is sufficient to say that the determination of the freezing point is free from experimental difficulties, such as oxidation, contamination, etc. The freezing point of zinc is more sharply defined than that of any other substance used for this purpose, and is probably the easiest of all fixed points to reproduce.

The New Jersey Zinc Co.  
Research Division.

<sup>1</sup>Bulletin Bureau of Standards, vol. 6, No. 2, pp. 164, 173.

<sup>2</sup>Bulletin 145, Bureau of Mines, p. 62.

<sup>3</sup>"Standardization of Rare-Metal Thermocouples," MET & CHEM. ENG., vol. 18, No. 7, p. 343, April 1, 1918.

# Melting Point Methods at High Temperatures—I\*

A Description of the Determination of Melting Points of Metals, Alloys, Salts and Refractory Materials by the Use of Thermo-Electric, Resistance and Optical Pyrometers

BY LEO I. DANA AND PAUL D. FOOTE

## INTRODUCTION

THE determination of a melting or freezing point, whether for a physical or physicochemical purpose, resolves itself into the measurement of a temperature under particular conditions and with appropriate technique. The accuracy and ease with which melting points at high temperatures may be determined are due to the comparatively recent developments in pyrometry, electric furnace construction and refractory materials.

The general classes of substances considered are metals, alloys, salts and refractory materials. For the temperature measurements, thermo-electric, resistance and optical pyrometers are employed, depending upon the temperature range and other controlling conditions.

The melting or freezing point of a pure crystalline substance is defined as the temperature at which the solid phase can remain in equilibrium with the liquid phase at normal atmospheric pressure. The effect of pressure is ordinarily insignificant; it is only when the pressure reaches many atmospheres that any change in the melting or freezing point can be readily detected. At the melting point there is a discontinuous change of a number of the physical properties of a material, e. g., thermal conductivity, electrical resistivity, specific volume, etc. In general, alloys, excepting eutectoids, mixtures of refractory oxides and materials with impurities, do not have a definite melting point, but become liquid gradually; that is, they melt over a temperature interval and consequently are considered as having a "melting range."

## I. Use of Thermo-Electric Pyrometers

### PURE MATERIALS

*General Discussion.* The experimental arrangement of this method consists of a crucible containing the substance in which a thermocouple, either protected or unprotected, is centrally inserted. The crucible is placed in a uniformly heated portion of an electric furnace. On account of cleanliness, clarity of the atmosphere and precision of control, electric resistance furnaces are preferable to gas- or fuel-fired furnaces for accurate melting point determination. When a melting or freezing point is to be observed, the temperature of the furnace is gradually raised or lowered and the temperature as indicated by the thermocouple is noted at frequent and preferably uniform intervals of time. If all conditions were ideal the temperature of the charge would remain constant during melting or freezing. Thus the temperature-time curve would be characterized by a straight line exactly parallel to the axis of time and by a discontinuous change of slope at either end of the line marking the beginning and ending of the period of

melting or freezing. Actually, however, the change of state shown by the curve, even for pure materials, is not sudden, but more or less gradual. Only a part of the freezing curve will be flat, and the melting curve usually possesses greater obliquity than the freezing curve. For this reason freezing point determinations are usually more reliable and are employed whenever possible, although the temperature thus obtained is frequently called the melting point, to which it is numerically equivalent.

The reasons for obliquity, and for its existence to a greater degree in the melting curves, have been discussed in detail by White.<sup>1</sup> On heating, the furnace walls are hotter than the crucible and hence heat flows from the furnace to the crucible. When a layer of the charge near the wall of the crucible reaches the melting point, the heat absorbed by the charge goes to supply that necessary for the latent heat of fusion, and the temperature of the outside layer tends to remain fairly constant. The thermocouple measures the temperature of the solid metal in the center of the charge and when thus surrounded by an isothermal layer the rate at which the inside temperature increases is greatly diminished, resulting in a rounding off of the temperature-time curve. As the isothermal layer progresses inward the temperature of the couple slowly rises until the material immediately surrounding it begins to melt, when a condition of stationary temperature is maintained for a short time during which the thermocouple reading gives the true melting point. While the center of the charge is melting, however, the temperature of the outer layer of material in the crucible rises very rapidly and a large temperature gradient is established between the outside and center. The resulting rapid flow of heat to the center of the crucible accelerates the melting and, if the layer of remaining solid metal is unequally distributed about the couple, tends to increase the temperature readings and cause another rounding off of the temperature-time curve. The apparent degree of obliquity found near the beginning and end of the melting period depends considerably on the sensitivity of the temperature measurements and scale of plotting. Thus highly accurate data obtained with a precision potentiometer may be plotted on so large a temperature scale that the curve may appear quite oblique, while the same data replotted on a less-extended scale appear fairly flat. Aside from this, however, the degree of obliquity varies according to the factors controlling the differences in temperature within the charge, such as dimensions and thermal properties, rate of heat supply, etc. If the solid metal could be stirred during a melting point determination the temperature gradients could be diminished, but even with powdered materials where

\*Part II will be published in the Jan. 14 issue.

<sup>1</sup>White, "Melting Point Determinations," *Am. J. Sci.*, vol. 28, p. 453; 1909.

stirring is possible it is not convenient and does not appear to be very satisfactory. The larger the diameter of the charge, the faster the rate of heating, the smaller the diffusivity and the less the latent heat of fusion the greater will be the tendency to obliquity. The obliquity may be decreased by slow heating and by using a charge of fairly small diameter. The protection tubes of the thermocouple should be small, of thin wall and should be deeply immersed in the charge. With metals the obliquity is not so great as with salts on account of their higher heat diffusivity and latent heat of fusion; in fact, for most cases the obliquity is of negligible importance with pure metals. But with salts and certain refractory materials, unless special care is taken, the obliquity may be so great as to obscure almost completely the true melting phenomenon.

On cooling, the crucible is hotter than the furnace walls, and heat flows from the crucible to the furnace. The outer layer of the charge solidifies first and during freezing acts as an isothermal layer, thus decreasing the temperature differences between the center and outside of the charge. The rate at which the temperature of the couple falls decreases, causing a rounding off of the first part of the temperature-time curve. While the center of the charge is freezing the outside is com-

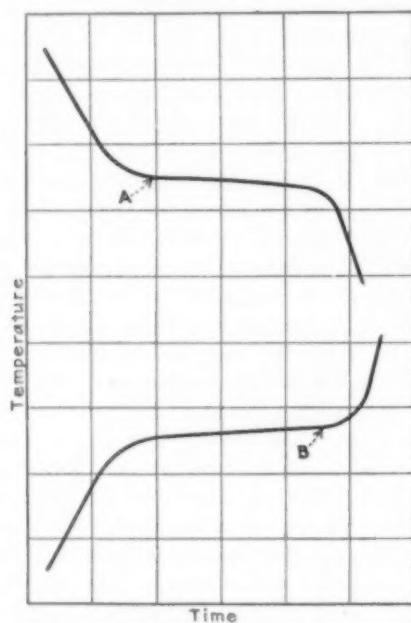


FIG. 1. OBLIQUE FREEZING AND MELTING CURVES

pletely frozen and rapidly falls in temperature, increasing the temperature gradient and the outward flow of heat, and hence the latter part of the freezing is accelerated.

The first part of the approximately flat portion of the curve for freezing corresponds to the true freezing point, and the latter part of the approximately flat portion of the curve for melting corresponds to the true

melting point. The same precautions of high narrow charges, narrow protecting tubes, sufficient depth of immersion and small thermocouple wires apply to both cases.

In general the freezing curves are more sharply defined than the melting curves. A liquid cooling and subject to convection currents is likely to possess a more uniform temperature distribution than a solid on heating. Furthermore, the freezing point is chosen at a time immediately following a period of small temperature gradients, while the melting point must be chosen

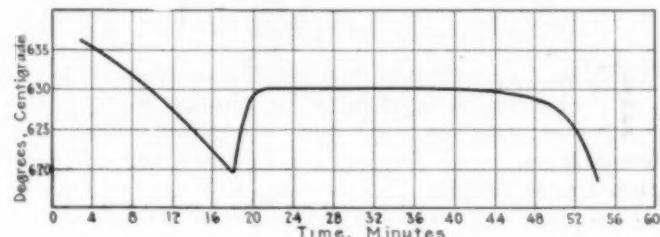


FIG. 2. FREEZING CURVE OF ANTIMONY SHOWING UNDERCOOLING

near the end of the period of melting, when there is possibility of temperature non-uniformity. A further factor of importance is the constancy of heat supply. On cooling with a furnace well insulated, the freeze may extend over a considerable time with all power supply shut off. The furnace thus acquires a uniform rate of cooling. In heating, however, the effect of slight variations in the power supply may alter the true character of the melting curve. Fig. 1 shows a freezing and a melting curve in which considerable obliquity is present. The true temperature for freezing is obtained by extrapolating the straight portion of the freezing curve and noting at what temperature A the continued straight line deviates from the observed curve. The melting point B is similarly obtained from the melting curve. The first part of the freezing curve and the last part of the melting curve determine these two temperatures, as stated above.

It is impossible to obtain satisfactory freezing curves with certain materials such as silicates on account of extremely slow crystallization, and the melting curves, even though frequently poorly defined, must be employed. The phenomenon of surfusion or supercooling is well illustrated by water, which may be cooled to -30 deg. C. without freezing. Surfusion is due to conditions which do not favor the attainment of equilibrium between the solid and liquid phases at the true freezing point. The conditions tending to produce equilibrium and the elimination of surfusion are slow cooling, stirring of the liquid and the presence of nuclei which serve as centers of crystallization. When a supercooled liquid freezes, it crystallizes very rapidly and the temperature rises to the true freezing point provided the supercooling has not proceeded too far. The

TABLE I.

Laboratory	Crucible Dimensions, All in Cm.				Charge Dimensions		Protection Tubes		Distance from Bottoms of Charge to Protection Tubes
	Inside		Outside		Diameter	Height	Diameter	Height	
	Diameter	Height	Diameter	Height			Outside	Inside	
Bureau of Standards	7	15	8.5	16	7.0	11	1.0	0.8	1.0
Geophysical	2.7	8	3.7	10	2.7	5	0.8	0.5	0.5
Bureau of Standards	1.2	3	2.0	3.5	1.2	2	0.15	0.1	0.3

subsequent freezing takes place in a normal manner. Surfusion in most metals seldom exceeds 0.1 or 0.2 deg. C., but in the case of antimony it is very marked and may amount to 30 deg., depending upon the rate of cooling, as shown by Fig. 2. Supercooling also occurs in alloys, especially in eutectics. While the contrary phenomenon of superheating is negligible with pure metals, it may become of importance with alloys, particularly in allotropic transformation and with salts and silicates.

**Precision Work With Pure Metals.** The primary method for the standardization of thermocouples consists in determining the e.m.f. developed by the couple at the freezing points of several very pure metals. The metals so employed are those the freezing points of which have been accepted as fixed points on the high temperature scale, e. g., tin, cadmium, zinc, antimony, aluminum, silver, gold, copper, etc. For this work and for the reverse problem of accurately determining the freezing points of metals and alloys the greatest precautions against contamination of the couple and the metal are required. Precision work at high temperatures requires the use of homogeneous platinum-90 per cent platinum, 10 per cent rhodium couples. The diameter of the wire usually employed is 0.5 or 0.6 mm., but for certain special purposes wires of 0.1 mm. are useful.

**Crucibles and Protecting Tubes.** Of all crucible materials Acheson graphite has the greatest utility. It is very pure, can be machined into any desired shape, and is not attacked by most of the common metals. At high temperatures the gases formed from its oxidation provide the reducing atmosphere necessary for the protection of the metal. Table I illustrates sizes of graphite crucibles which have been used in various investigations. For resistance thermometry the largest size shown is necessary, but for general work the intermediate size shown is recommended. In this case a smaller protecting tube is desirable, for example, one with an outside diameter of 5 mm.

Some metals, such as nickel and iron, combined with graphite, and certain other metals also should not be heated under the reducing conditions present with graphite. Crucibles of magnesia, alumina or mixtures of the two are suitable for iron and nickel. Porcelain crucibles may be used for many of the metals, but there is always danger of these cracking when the metal melts or freezes.

Up to 500 deg. C. protection tubes and insulating tubes for the couple made of pyrex glass are useful. From 500 to 1100 deg. C., lower grade porcelain glazed on the outside only or fused quartz are satisfactory. Above 1100 deg. C. tubes having a composition approxi-

mating that of sillimanite,  $\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$ , are recommended.<sup>2</sup>

Porcelain tubes, or crucibles, or any material containing silica cannot be used in contact with aluminum, as the silica is readily attacked. Aluminum may be melted in a graphite crucible and the porcelain protecting tube itself may be protected by a very thin sheath of graphite. Fig. 3 illustrates one convenient manner on which the sheath may be mounted in the crucible. The sheath is held down in the metal by the weight of the cover and is allowed to remain in the crucible after the aluminum is frozen. The thermocouple protecting tube fits tightly inside the sheath. At present there is no satisfactory protecting tube for nickel. This material and its alloys can be best studied by optical methods.

**Table of Melting Points.** Table II lists the more common metals the melting points of which can be used for the standardization of thermocouples by the crucible method.

<sup>2</sup>Such porcelain is made by Stupakoff Laboratories, Pittsburgh, under the trade name "Usalite," and by Charles Engelhard Co., New York, under the trade name "Impervite."

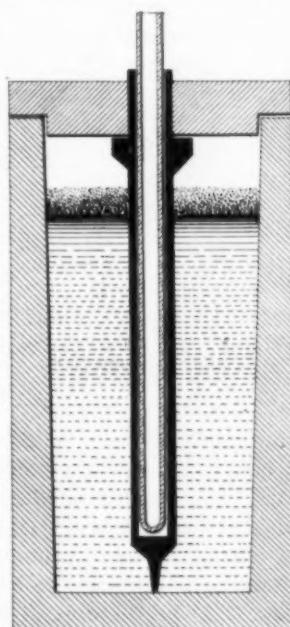


FIG. 3. GRAPHITE SHEATH FOR PROTECTION OF PORCELAIN TUBE IN ALUMINUM

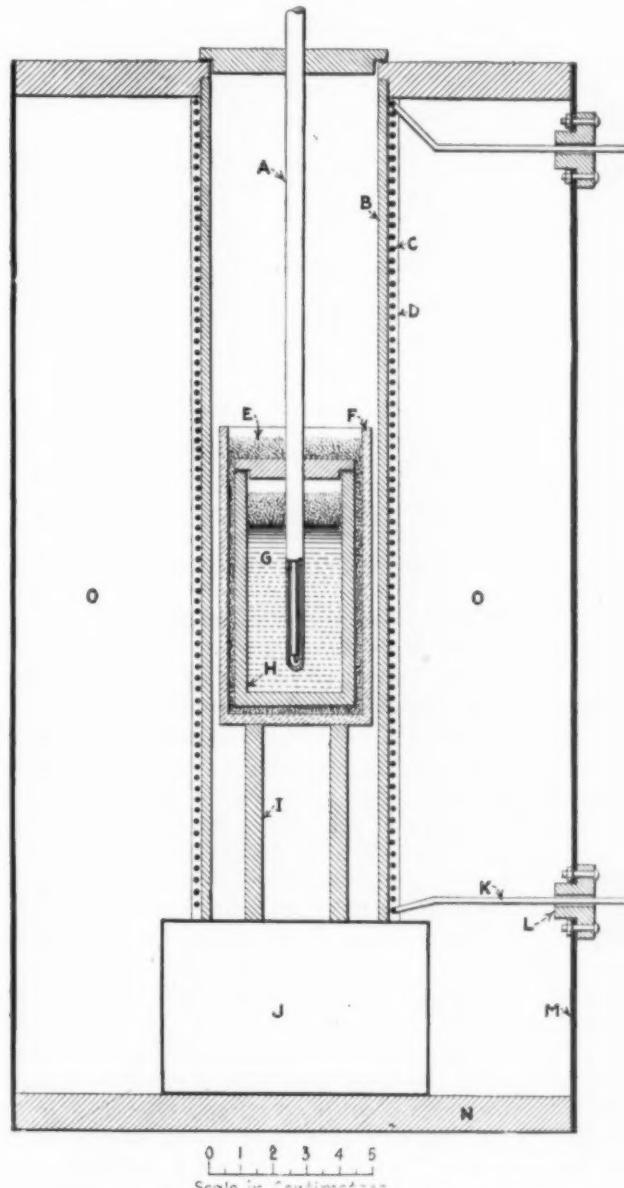


FIG. 4. MELTING POINT FURNACE FOR METALS AND ALLOYS

TABLE II.

Metal	Melting Point, Deg. C.	Crucible Material	Atmosphere
Tin	231.9	Graphite, porcelain or pyrex glass.	Reducing, neutral or air
Bismuth	271	Graphite, porcelain or pyrex glass.	Reducing or neutral
Cadmium	320.9	Graphite, porcelain or pyrex glass.	Reducing or neutral
Lead	327.4	Graphite.....	Reducing or neutral
Zinc	419.4	Graphite.....	Reducing or neutral
Antimony	630.0	Graphite.....	Reducing, CO
Aluminum	658.7	Graphite.....	Reducing, CO
Silver	960.5	Graphite.....	Reducing, CO
Gold	1063.0	Graphite.....	Reducing, neutral or air
Copper	1083.0	Graphite.....	Reducing, CO
Nickel	1452	MgO, Al <sub>2</sub> O <sub>3</sub> , or mix- tures of the two	H <sub>2</sub> , N <sub>2</sub> , or vacuum

The surface of the metal should be covered with a layer of powdered or flaked graphite, and the crucible should be provided with a cover having a hole through which the thermocouple tube is inserted. Under no circumstances should graphite be exposed to an air current above 500 deg. C., as it readily oxidizes and crumbles away. The furnace should be tightly closed at the bottom and no larger openings exposed at the top than

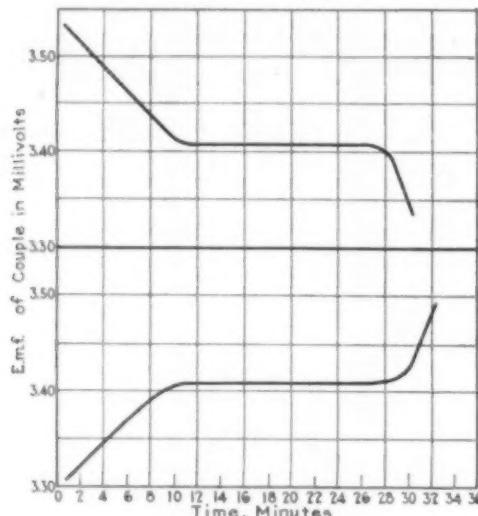


FIG. 5. FREEZING AND MELTING CURVES OF PURE ZINC

absolutely necessary. When fairly small graphite crucibles are employed it is frequently desirable to use a larger outside crucible of porcelain and fill the space between the two crucibles with graphite powder.

*Construction of Furnace.* Fig. 4 shows the construction of a furnace using crucibles of the intermediate size given in Table I for operation up to 1100 deg. C. The graphite crucible *H* containing the metal *G* and the pyrometer tube *A* rest in a porcelain crucible *F* and are completely covered by powdered graphite *E*. The porcelain crucible is supported in the alundum tube *D*. The heater tube is of alundum, R. A. 98, length 25 cm., inside diameter 5 cm. and wall thickness 3 mm. This is preferably corrugated on the outside and is wound with 60 to 80 turns of No. 14 "Chromel A" wire, *C*, to the ends of which are welded the lead-in terminals *K* of No. 10 Chromel. The alundum tubes *B* and *D* rest on a good-conducting fire brick about 5 x 8 x 8 cm. The shell *M*, 32 cm. high, is of sheet iron or monel metal painted with aluminum paint. The ends of the shell are closed by impregnated asbestos boards *N*, 1 cm. thick and 17 cm. in diameter. The annular space *O* is packed with sil-o-cel powder. The lead-in wires are insulated from the metal shell by asbestos board or steatite bushings.

The furnace in series with a rheostat for control may be operated on 110 volts and consumes about 1 kw. at 1100 deg. C.

Larger furnaces are required for the large crucibles described in Table I. Such a furnace may be constructed from the following stock material: Alundum tube, R. A.

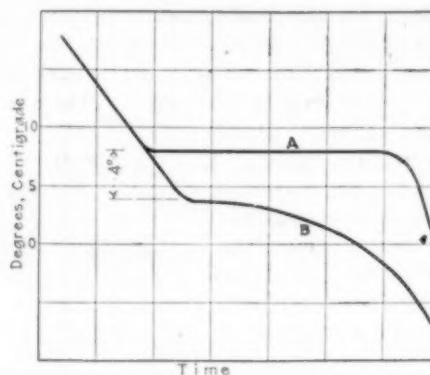


FIG. 6. FREEZING CURVES WITHOUT AND WITH IMPURITY

98, length 45 cm., inside diameter 8 cm., wall thickness 6 mm. Chromel A winding No. 5 wire; 60 turns separated by asbestos cord and covered over with a layer of alundum cement. Diameter of shell 36 cm.; height of shell, 60 cm.; sil-o-cel powder insulation, general construction similar to Fig. 4. Power required for 1100 deg. C. about 55 amp. at 60 volts. Using the large crucibles a freeze of copper with all power off extends over a period of about 20 minutes.

*General Precautions.* In order to melt for the first time a metal which is in small pieces, the graphite crucible, filled with the material, fitted with a cover having a hole in which the thermocouple fits tightly, and surrounded by powdered graphite, is slowly heated. If convenient CO or N<sub>2</sub> may be passed into the furnace, but CO<sub>2</sub> should not be used. The surface of the metal should not be covered with graphite at first, as it may filter into the interior and become imprisoned there. When the metal has been melted, however, the graphite

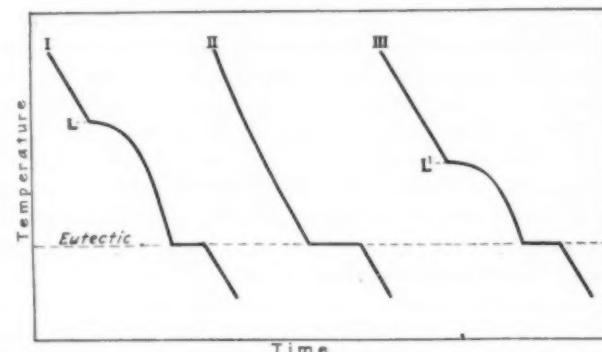


FIG. 7. FREEZING CURVES OF SIMPLE EUTECTIC ALLOYS

layer on the surface is quite desirable. With the exception of antimony, which should be stirred just as the freezing point is reached to reduce supercooling, it is not advisable to stir the molten metals, as pockets of graphite are thereby formed.

If there is doubt concerning the proper depth of immersion, several determinations should be made at different depths until a position is found where a slight variation does not affect the temperature measurement.

The pyrometer tube may be allowed to remain in the metal for a few degrees below the freezing point without breaking, and if it cannot be removed then, the metal should be immediately remelted.

A uniform rate of cooling of about 2 deg. C. per minute from 10 deg. C. above the melting point is satisfactory for a freezing point determination. The values obtained from melting and freezing curves should agree to from 0.1 to 0.01 deg. for pure metals, and the curves should have a flat portion extending over at least 10 minutes. If the curve is not fairly flat, the metal is likely impure and hence possesses a melting range instead of a true melting point. Fig. 5 illustrates an observed freezing and melting curve for zinc. The freezing curve is constant to 0.05 deg. C. for a period of 15 minutes and the melting curve for 10 minutes. The obliquity in the latter part of the melting curve amounts to 0.1 deg. in 6 minutes.

#### METALS WITH IMPURITIES, AND ALLOYS

An impurity in a metal usually lowers the melting point and produces obliquity in the melting and freezing curves, the magnitude of both of these effects increasing, within limits, as the amount of impurity is increased. Assuming the amount of impurity is small and that an ideal solution with the metal in the liquid state is formed, the lowering of the freezing point  $\Delta t$  may be expressed approximately by the Raoult-Van't Hoff equation:

$$\Delta t = \frac{R\Theta^2}{L} \cdot \frac{N_1}{N}$$

in which  $R = 1.99$ ,  $\Theta$  = absolute temperature of the freezing point of the pure metal,  $L$  = molar latent heat of fusion of the pure metal,  $N_1$  = number of mols of impurity, and  $N$  = number of mols of pure metal. In Fig. 6,  $A$  represents the freezing curve of a pure substance and  $B$  the curve obtained when an impurity is present. The lowering of the freezing point is 4 deg. C., an amount readily caused by a few tenths of 1 per cent of an impurity at about 800 deg. C. In general, the above equation for freezing point lowering holds only for an impurity which forms the simplest type of eutectic alloy with the pure metal. Evidently it cannot be applicable to those impurities which are wholly or partly soluble in the metal in the solid state, that is, which form solid solutions, for in some of these cases the melting point is raised by the addition of the impurity, as for example nickel added to copper.

For most of the common metals the oxide is insoluble in the pure metal, but with copper this is not the case, and special care must be taken, preferably by the maintenance of a strongly reducing atmosphere, to avoid the formations of cuprous oxide,  $Cu_2O$ . This oxide forms a eutectic with copper saturating it at 3.45 per cent of  $Cu_2O$  or 0.395 per cent of oxygen by weight, and freezing at 1063 deg. C. As an example of the application of the above equation, the freezing point lowering of copper at the eutectic, considering the  $Cu_2O$  as the dissolved impurity, will be calculated.

$$\Delta t = \frac{R\Theta^2}{L} \cdot \frac{N_1}{N} = \frac{2 (1083 + 273)^2 (2.19)}{(63.6) (43.3) (143)}$$

$$\Delta t = 20.4 \text{ deg. C.}$$

The lowering found experimentally is 20.0 deg. C.

If the copper contains only a small amount of the oxide, the first solidification begins slightly below the melting point of pure copper and crystals of copper

separate from the solution. The concentration of the dissolved impurity  $Cu_2O$  accordingly increases, so that the freezing point of the remaining part of the solution is still lower. The pure copper will continue to separate from the liquid at a gradually decreasing temperature until the solution becomes saturated with  $Cu_2O$ . This results in rounding or obliquity of the cooling curve. When the remaining solution is saturated, both the Cu and the  $Cu_2O$  solidify together, at a constant temperature, as a eutectic mixture. At this point a halt occurs in the cooling curve, the magnitude of which depends upon the amount of the eutectic present. The effect of a small amount of  $Cu_2O$  will escape notice in an ordinary melting point determination, but if considerable oxide is present the freezing curve shows the two retardations, one below 1083 deg. and the other at 1063 deg. C. Observation continued through the latter point may serve as a rough criterion of the purity of copper suspected of contamination by its oxide. The obliquity of the curve also may be an indication of impurity. If a copper wire is slowly heated in air, the melting usually

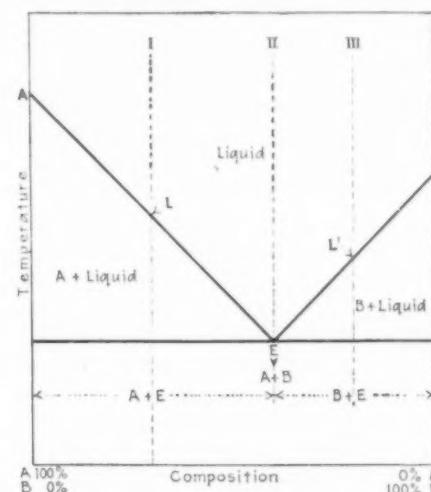


FIG. 8. TEMPERATURE-COMPOSITION DIAGRAM OF SIMPLE EUTECTIC ALLOY

begins at the eutectic point 1063 deg. instead of at 1083 deg. C.

Oxygen dissolves in silver and may lower the melting point as much as 5 deg. C. if the silver is heated in air.

An alloy may be considered as a metal containing large proportions of one or more impurities. Let us consider the simplest case of an alloy of two metals  $A$  and  $B$  which are mutually soluble when liquid and insoluble when solid. If  $A$  first begins to separate from the solution, the remaining liquid becomes richer in  $B$ , and as shown above, this part of the freezing curve gradually changes in slope as illustrated by Fig. 7, Curve I,  $L$ . As the temperature is lowered the solution finally becomes saturated with  $B$ , and  $A$  and  $B$  crystallize together as a eutectic, shown in Fig. 7 by the lower flat portion of the cooling curve. The alloy accordingly has a melting or freezing range extending from the temperature at which separation of  $A$  first begins to the temperature at which the eutectic mixture solidifies. If the original composition of the alloy is the eutectic mixture, there exists a true melting point as shown in Fig. 7, II, and not a melting range.

The general form of the temperature-composition diagram of the simple binary alloy described above is illustrated by Fig. 8. The curves I, II and III, of Fig. 7 show

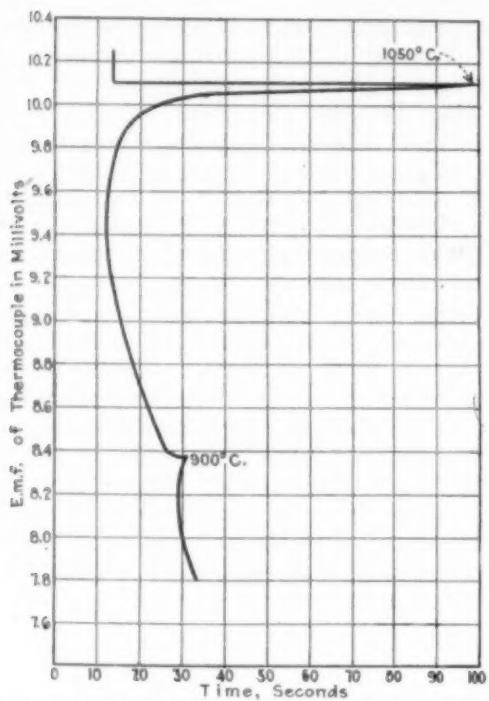


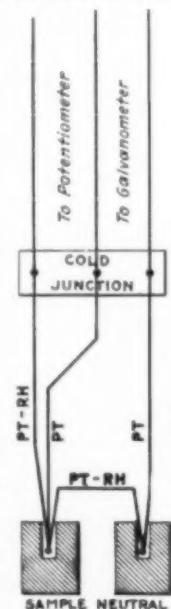
FIG. 9. INVERSE RATE CURVE OF A BRONZE

the form of the cooling curves obtained with the alloys of compositions I, II and III of Fig. 8.

Often a binary alloy exhibits two halts in the melting and freezing curves, one oblique and one flat, or both oblique. Furthermore, other complications may arise, such as the formation of solid solutions, compounds and allotropic transformations accompanied by heat changes which require more sensitive methods of detection than by a simple cooling curve. In general the larger the melting range in a binary alloy the more difficult it becomes to locate the lower transformation point because of the small amount of crystallization per degree drop in temperature and the resulting small heat effect. The same general details for melting point of pure metals apply to alloys. The eutectic alloy Ag-Cu, 71.9 per cent Ag, 28.1 per cent Cu, melts at 779 deg. C. and is useful as a standardization temperature for thermocouples.

For alloys having a large melting range, accurate control of the rate of heating and cooling is essential. Automatic control of the rate may be obtained by a salt water rheostat as applied by Burgess and Crowe,<sup>3</sup> or an automatic magnetic control system may be installed. Scott and Freeman<sup>4</sup> describe a modified Rosenhain furnace for critical point work. This consists of a vertical tube furnace, with a uniform temperature gradient, through which the material is automatically moved at a definite rate.

If the ordinary temperature-time curve does not give evidence of a change of state at the beginning or end of a melting range or at a transformation point, the more sensitive means of detection, such as the inverse-rate method and differential method, may be employed.

FIG. 10  
DIAGRAMMATIC  
REPRESENTA-  
TION OF  
DIFFERENTIAL  
METHOD

The former consists in determining the time required for the specimen to fall a definite temperature interval, and in plotting this time against the temperature. The experimental arrangements are the same as for the ordinary time method, except that the time must be measured more accurately. Merica<sup>5</sup> has described a device consisting of two stop watches, one of which is stopped and started at the end of each time interval. Fig. 9 shows an inverse rate curve through the melting range of a bronze. The lower transformation at 900 deg. C. could not be detected by the ordinary temperature-time method.

The differential method is still more sensitive to small thermal changes. This consists in measuring the temperature differences between the material in which the transformation takes place and a neutral body having no transformation points in the same temperature interval, such as platinum or nickel, and plotting this difference against the temperature of the material. Two thermocouples are employed as illustrated by Fig. 10, one a differential couple and the other an ordinary

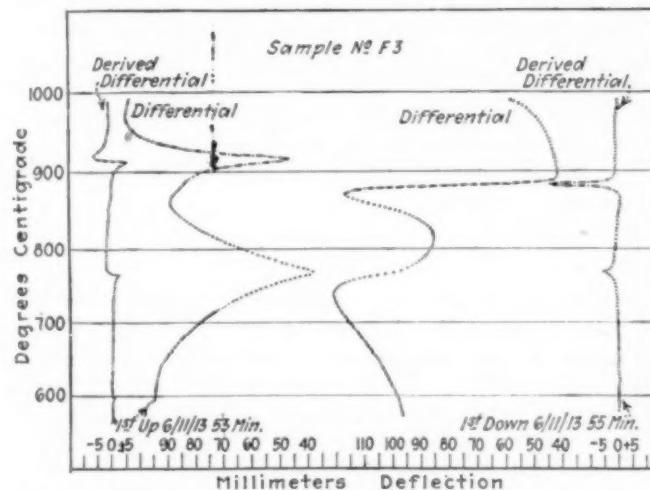


FIG. 11. COMPARISON OF DIFFERENTIAL AND DERIVED DIFFERENTIAL METHODS

couple which measures the temperature of the sample under investigation. By use of a sensitive galvanometer with the differential couple, extremely minute thermal transformations may be easily detected. Slight variations in the rate of heating produce no noticeable effect.

Another method of interpreting the data is by means of the derived differential curve, first suggested by Rosenhain.<sup>6</sup> This amounts to differentiating the differential curve in respect to the temperature and plotting the value so obtained against the temperature. The derived differential is accordingly related to the differential curve in the same manner that the inverse rate is related to the temperature-time curve. Thus if  $\theta$  is the temperature of the neutral body, the derived differ-

tial is the graph  $\frac{d(\theta - \theta')}{d\theta}$  vs.  $\theta$ . The method consists in observing successive values of  $(\theta - \theta')$  for equal increments of  $\theta$ , say 2 deg. C., and plotting successive differences  $(\theta - \theta')$  against  $\theta$ . The experimental arrangement is the same as that required for the differential method. Fig. 11 shows both differential and derived differential curves for the same sample of pure iron at the transformation points  $A$  and  $A_2$ .

<sup>3</sup>Bu. of Standards, Scientific Paper No. 213.  
<sup>4</sup>Burgess, A. I. M. E., August, 1919.

<sup>5</sup>Bull., A. I. M. E., July, 1919.

<sup>6</sup>Burgess, Bu. of Standards, Scientific Paper No. 99.

## Present Status of American Glassware\*

**The American Pre-War Contribution to the Progress of the Glassware Industry Was Limited Mostly to Art Glass, Selenium-Red and Other Color Glass and Low-Expansion Glass; Now America Excels in the Manufacture of Glass and Glassware for All Practical, Industrial and Scientific Uses**

BY E. C. SULLIVAN

**A**MERICA had achieved certain results in glass chemistry before the war, but stimulus of necessity arising from the shutting off of foreign supplies both in glassmaking materials and of finished glasses has brought about more than ordinary progress during the past few years. As a result this country seems fully abreast of its competitors and in some respects has forged ahead, producing ware of better quality at no increase in price to the consumer and pushing development beyond that reached abroad.

America has long been the acknowledged leader in ornamental cut-glass, no other country having equaled the brilliance and richness of the American product.

An art glass which had its origin in America is the well-known Aurene or Favreuil glass, a glass of golden iridescence produced by spraying upon the surface of the finished article a liquid which reacts with the constituents of the glass and produces very remarkable soft color effects. It is made into vases, bowls for indirect lighting, etc.

### COLORED GLASSES

A development of very great importance in the field of colored glass which owes its origin to America is the selenium ruby. Selenium, as is well known, is a rare element which is obtained chiefly as an impurity which separates from copper when that metal is refined electrolytically. It was discovered by a Pittsburgh glass maker that under certain conditions selenium could be made to produce a clear red of almost any depth desired. The selenium red has the great advantage for railway signal work that it transmits practically all the red rays and except for some yellow nothing else. In other words, it is a color filter. Other red glasses transmit other parts of the spectrum in addition to red. Gold ruby, for instance, transmits the red rays incompletely and at the same time lets some blue light pass. The selenium red is used universally by railways in this country for the danger signal, and tons of the comparatively rare element are consumed annually in preparing the glass.

In other railway signal glasses also this country is well in the lead, both in design of the semaphore lens and in production of the most efficient colors. Time was when each railroad had its own set of signal colors, the greens, for instance, ranging from blue-green to a yellow chrome-green, while the yellows varied from a reddish yellow to a green-yellow not far removed in hue from some of the yellow-greens. To straighten this confusion the glassmaking chemist called to his assistance the physicist and the physiological psychologist, and after years of collaboration the result today is for each color a universally adopted standard hue which affords maxi-

mum light transmission and maximum distinctiveness. The standard green gives more light than any other green and is less likely than any other green to be mistaken for another color, as yellow or blue. Similar standards now exist for each signal color. By the redesigning of the semaphore lens and the employment of the so-called high-transmission colors the intensity of the color-signal has been very greatly increased.

### LOW-EXPANSION GLASSES

Another advance in glassmaking due to America was the introduction of low-expansion so-called heat-resisting glass for railway lantern globes. A trainman's lighted lantern set down on the car-platform or in the caboose is not unlikely to rest on a projecting brake-ratchet or on a broom handle, the result being that the flame plays directly against the glass. Then when the lantern is taken out into the rain or snow the overheated glass cracks and the signal fails—which in an emergency may be a matter of life or death. Chimneys of a thin glass of low expansion had been successfully used abroad. This glass, however, did not meet satisfactorily the severe conditions to which the thick-walled lantern-globe was subjected in service, and a glass was developed in this country for lantern-globes lower in expansion than any glass which had been made in commercial quantities up to that time. The low-expansion globes, both colorless and colored, are practically the only ones in use at present.

### GLASS FOR ELECTRIC LIGHT BULBS

Potash glass had always been considered essential for incandescent electric light bulbs, of which hundreds of millions are used annually. Glass chemists had developed non-potash glasses which appeared to have the same properties as the potash glasses, but the uncertainties involved in so radical a change were thought to outweigh the advantages, until the war, by excluding foreign potash, made action imperative. The non-potash glass has now been in use for some years and in many respects gives better results than the potash glass which it replaced. Except for certain special purposes a return to potash glass for bulbs in the future seems very doubtful.

This non-potash bulb-glass, however, like the potash glass and like all bulb-glasses from the beginning, contained 20 per cent or more of lead. One objection to the use of lead in glass is its cost. Even at its pre-war price of about 4c. per lb., it was an expensive glass-making material, and during the war this price was doubled and trebled. Another drawback is the fact that among glassmakers there is a tradition that lead glass must be melted in pots and cannot be melted in a tank. Pot-melting is the old inefficient method of making glass, while tank-melting is the modern continuous op-

\*Read at the Chemical Exposition, Chicago, Sept. 23, 1919.

eration adapted to the use of automatic conveying machinery for materials and to machine methods of working the glass. Two or three years ago a tank-melted bulb-glass was successfully introduced which contained neither potash nor lead, and its use has extended until a very large proportion of all lamp bulbs are now made of comparatively inexpensive materials by efficient labor-saving methods adapted to large-scale production.

#### SELECTIVE SPECTRUM-ABSORBING GLASS

In the field of glasses for transmitting or absorbing certain definite portions of the spectrum America appears to be at least abreast of her competitors.

There has been a demand for a glass which while absorbing as little of the visible spectrum as possible would afford the eye complete protection from the short wave-length ultraviolet. This has been accomplished in this country by development of a very pale but brilliant yellow glass which absorbs ultraviolet almost completely.

The glass just mentioned absorbs ultraviolet and transmits the visible light. Another recent American glass is unique in that it transmits ultraviolet and absorbs the visible. This ultraviolet has been called the invisible purple and is for the most part invisible. If all other light is excluded from the room, the radiation from an electric arc transmitted by this glass causes in the eye a puzzling and rather weird sensation of haze, owing to the fact that the eye cannot bring the rays to a focus as it can those of the visible spectrum. The weirdness is heightened by the ghastly appearance of teeth, eye-balls, finger-nails, etc., which like other fluorescent substances such as uranium glass, anthracene, rhodamite, willemite, change the invisible ultraviolet to visible light, which they radiate.

#### WELDERS' GLASSES

For protection of operators of the electric-arc welding process from the radiation which if not guarded against causes serious burns of the skin and injury to the eyes, "welders' glasses" have been worked out which absorb not only ultraviolet but also infra-red and such excess of the visible light as causes glare. The light transmitted by these glasses is in the yellow green of the spectrum, in which visual acuity is highest.

Another unique glass absorbs only the infra-red. It is of pale-green color and transmits most of the visible, but in thickness of only 2 mm. absorbs 95 per cent or more of the invisible heat-rays. A piece of carbon paper so held in the rays from a projection lantern as to take fire almost at once is protected indefinitely if this glass is interposed. Ordinary glass is entirely ineffective. Eyeglasses of the heat-absorbing glass have a wonderfully comfortable and cooling effect in high-temperature work.

#### X-RAY SHIELD GLASS

Various new glasses were developed to meet exigencies which arose during the war. One was a glass for X-ray shields which had about one-third the protective power of metallic lead of the same thickness and was the most effective glass used for the purpose up to that time. It formed part of a portable X-ray outfit used effectively close to the front lines in France. Colored glasses for marksmen, for naval gunners and for aviators, sextant glasses, special Fresnel ship lights, were other developments for direct use in connection with

the war, and there were others which for military reasons are still held confidential.

#### CHEMICAL AND COOKING UTENSILS GLASSWARE

The first high-grade chemical glassware made in this country was produced as long ago as 1902. It was fully equal to the best imported ware in resistance to chemical attack and was a low-expansion glass which could be heated directly over the flame without breaking. For 17 years, therefore, chemical glassware has been made in this country which for all practical purposes was on a par with the best foreign ware.

During the war other chemical glasses were put on the market, and today according to the findings of the Bureau of Standards at Washington better chemical glassware is made in this country than was ever imported.

With regard to resistance to chemical attack, the Bureau investigated flasks and beakers of five American brands with nine reagents each. Allowing one point for each of the 90 comparisons thus possible, the American brands score 60 points against 25 for the best foreign, 5 points being tied. Expressing the result in other words, this is equivalent to the American glasses having made a better showing in six of the nine reagents, an equal showing in one-half of one reagent, and a poorer showing in 2½ of the nine.

In power to withstand sudden cooling and in mechanical strength three American brands were found superior to the foreign, one of the American being far superior to all others in mechanical strength.

Apparatus built of the same glass used for flasks and beakers gave good service to chemical manufacturers during the war.

An expression from the Army medical authorities may be quoted as fairly typical of the enthusiasm of users of the American ware. They wrote that American flasks for preparing typhoid vaccine were far ahead of any such flasks ever obtained abroad; that the American glass had met the requirements so thoroughly that "aside from any sentimental reasons we would not take the foreign flasks if they were given to us."

In the same connection may be cited the fact that representatives of the American Chemical Society, the principal users of chemical glassware, appeared before the Ways and Means Committee of the lower house of Congress to urge that the domestic industry be fully protected by abolition of all duty-free importation of chemical glassware.

The glass baking-dish is a purely American development which seems to have established a permanent place for itself. The glass must possess the same qualities which are necessary for high-grade chemical glassware—resistance to the attack of water and dilute acids and alkalis, and low expansion-coefficient. A broad patent has been issued by the United States Patent Office on this invention. The unexpected feature of these dishes is the fact that baking takes place more rapidly in the glass than in metal, which has been shown to be due to the fact that glass reflects but a small per cent of the oven heat which is radiated upon it, while a metal utensil reflects 90 per cent or more of such heat.

#### POTS FOR GLASS MELTING

Before the war German clay had been considered essential to the manufacture of glass pots, but American clay pots are giving in every respect fully as satisfactory service as was had from the imported material.

## A Rapid Method for the Analysis of Monel Metal

BY PHILIP COVITZ

**B**Y COMBINING various well known rapid volumetric and gravimetric methods, an important saving of time without sacrificing accuracy is assured in analyzing monel metal, an approximate average percentage composition of which is:

Cu, 20 to 30; Ni, 60 to 70; Fe, 0 to 3.5; Al, 0 to 0.5; Mn, 0 to 3.5; C + Si, 0 to 0.8.

The usual procedure has been to dissolve a weighed quantity of the alloy (usually 1 gram) in nitric acid, filter off the silica and carbon, electrolyze the filtrate for copper, remove iron, aluminum and manganese by brominating the ammoniacal electrolyzed solution, redissolve the precipitate and separate the elements; and finally determine nickel by the glyoxime method in the filtrate from the various precipitations. Carbon was obtained in a separate sample.

### SEPARATE DETERMINATIONS

Inasmuch as all elements except carbon were determined on the same sample, precipitations and reprecipitations and washings resulted in the accumulation of large volumes of filtrates, which required considerable evaporation. The loss of time in concentrating filtrates should be avoided. In the method described below, this time factor is considerably reduced.

*Carbon* is determined by direct combustion in the Fleming apparatus.

*Silicon* is determined by filtering solution of metal before electrolysis, and ignition of the precipitate in a muffle.

*Manganese* is obtained by the bismuthate method on a separate sample.

*Copper* is found by usual electrolysis.

*Nickel* is determined directly on a separate sample, none of the elements interfering.

*Iron* and *aluminum* are separated from other elements in the solution of a separate sample, by precipitation with  $\text{NH}_4\text{OH}$  in presence of  $\text{NH}_4\text{Cl}$ . The precipitate is dissolved and the iron separated from the aluminum by boiling with KOH. The iron is then determined by the Zimmerman-Reinhardt process, while the aluminum is determined as  $\text{Al}(\text{OH})_3$  in the filtrate from the  $\text{Fe}(\text{OH})_3$ .

### DETERMINATION OF SILICON

Weigh 1 g. of monel shavings into 200 cc. beaker, add 10 cc.  $\text{HNO}_3$  (1.42), heat until dissolved and evaporate to approximately 7 cc. Dilute to 50 cc. with hot  $\text{H}_2\text{O}$ , filter through No. 42 Whatman 12.5 cm. paper into 300 cc. beaker. Wash thoroughly with hot  $\text{H}_2\text{O}$ , keeping volume of filtrate below 150 cc. Ignite and weigh  $\text{SiO}_2$ . If precipitate is heavy and discolored treat with HF and determine loss.

Per cent Si =  $46.9 \times \text{SiO}_2$  ppte.

This method is open to criticism in that the silica is not dehydrated. In the opinion of the writer dehydration in most cases for silicon in monel metals is unnecessary. If the analyst should prefer it, however, the following procedure should be adopted:

Weigh 1 or 2 g. of borings in porcelain dish, add 10 cc.  $\text{HNO}_3$  (conc.) and 5 cc.  $\text{H}_2\text{SO}_4$  (conc.), evaporate cautiously to dryness, and heat until  $\text{H}_2\text{SO}_4$  fumes

freely. Cool, dissolve in 10 cc. conc. HCl, dilute to 50 cc. with hot  $\text{H}_2\text{O}$ , filter, wash with hot 1 to 1 HCl and hot  $\text{H}_2\text{O}$ , dry, ignite in muffle and weigh  $\text{SiO}_2$ . Do not use this filtrate for electrolysis.

### COPPER

Cool filtrate from  $\text{SiO}_2$ , make up to 150 cc., and add 5 cc. 1 to 1  $\text{H}_2\text{SO}_4$ . Electrolyze, using a current of 1.5 amp. for 2 hours. Rinse electrodes, wash with  $\text{C}_2\text{H}_5\text{OH}$ , dry one minute in oven at 110 deg. C. and weigh deposited copper.

### IRON AND ALUMINUM

Weigh 1 g. of borings into 500 cc. beaker, add 10 cc.  $\text{HNO}_3$ , heat until dissolved, and dilute to 250 cc. with hot  $\text{H}_2\text{O}$ . Add 5 g.  $\text{NH}_4\text{Cl}$ , make ammoniacal, and boil 5 to 10 minutes. Allow precipitate to settle and filter through No. 40 Whatman paper (12.5 cm.). Wash thoroughly with hot  $\text{H}_2\text{O}$ . Reject filtrate. Transfer bulk of precipitate back to original beaker, pour hot 1 : 1 HCl through filter, and catch solution in this beaker. Wash paper free from iron. Warm beaker gently (do not boil). When precipitate has dissolved dilute to 250 cc. with hot  $\text{H}_2\text{O}$ , add 3 g.  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{OH}$  in excess. Boil 5 to 10 minutes, allow precipitate to settle and filter through No. 40 paper. Wash thoroughly with hot  $\text{H}_2\text{O}$ . Discard filtrate. Again dissolve precipitate as before, using as little HCl as possible, and wash filter thoroughly. Heat gently until iron is dissolved and add slight excess of 50 per cent KOH. Dilute to 150 cc. and boil 5 to 10 minutes. Let settle, filter through No. 40 and wash thoroughly with boiling  $\text{H}_2\text{O}$ . Save filtrate.

### IRON

Place paper containing precipitate of  $\text{Fe}(\text{OH})_3$  into original beaker, add 10 to 15 cc. HCl and warm gently until precipitate dissolves. Add from dropper  $\text{SnCl}_4$  solution drop by drop until decolorized, and then add 10 cc.  $\text{HgCl}_2$  solution. Wash into 800 cc. beaker containing 400 cc. cold  $\text{H}_2\text{O}$  and 20 cc. preventive solution. Dilute to 600 cc. and titrate immediately with 0.03N  $\text{KMnO}_4$  to end point which remains one minute. Conduct blank titration using same quantities of reagents.

To prepare 0.03N  $\text{KMnO}_4$  dissolve 2 g. permanganate in  $\text{H}_2\text{O}$  and dilute to 2 liters; standardize vs. sodium oxalate. Preventive solution: dissolve 160 g.  $\text{MnSO}_4$  in  $\text{H}_2\text{O}$ , dilute to 1750 cc.; add 330 cc. syrup  $\text{H}_3\text{PO}_4$  (1.7) and then 320 cc.  $\text{H}_2\text{SO}_4$  (1.84). Stannous chloride: dissolve 150 g.  $\text{SnCl}_4$  in 250 cc.  $\text{H}_2\text{O}$  and 250 cc. strong HCl. Mercuric chloride: make up saturated solution with hot  $\text{H}_2\text{O}$ , allow to cool and filter.

### ALUMINUM

To the filtrate from the  $\text{Fe}(\text{OH})_3$ , add strong HCl in excess and boil thoroughly 10 to 15 minutes. Add excess  $\text{NH}_4\text{OH}$  and again boil 15 minutes. For small amounts of  $\text{Al}(\text{OH})_3$  it may be necessary to prolong the boiling and, in cases of traces of aluminum, standing over night in warm place is advisable. Filter off, wash precipitate thoroughly with hot  $\text{H}_2\text{O}$ , dry, ignite, and weigh as  $\text{Al}_2\text{O}_3$ .

Per cent Al = wt. ppte.  $\times$  53.03

In some instances a trace of iron may dissolve on boiling the iron aluminum solution with KOH. This will of course show up with the  $\text{Al}_2\text{O}_3$ . In the event of any significant amount of  $\text{Fe}_2\text{O}_3$  in the  $\text{Al}_2\text{O}_3$  precip-

itate, purification may be obtained by fusing the combined oxides with KOH in a silver dish, dissolving the fusion in hot water and filtering off the  $\text{Fe}_2\text{O}_3$ . Aluminum may then be determined as indicated above.

#### MANGANESE

Weigh 1 g. borings into 300 cc. Erlenmeyer flask, add 20 cc.  $\text{HNO}_3$ , heat until dissolved and dilute to 60 cc. with hot  $\text{H}_2\text{O}$ . Add 1 g. sodium bismuthate and boil 5 minutes, or until permanganate color which forms is changed to brown. Now add 1 g.  $\text{FeSO}_4$  and boil until brown fumes are expelled and the solution resumes its green color. Cool under tap to room temperature, add 1 g. bismuthate, agitate, and allow to stand 5 minutes. Filter by suction through asbestos and wash with 50 cc. 3 per cent  $\text{HNO}_3$ . Dilute filtrate to 300 cc. and titrate with ferrous ammonium sulphate solution to the disappearance of the permanganate color. A few trials will produce a satisfactory end point.

To prepare ferrous ammonium sulphate dissolve 30 g.  $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$  in cold  $\text{H}_2\text{O}$ , make up to 2 liters and add 75 cc. concentrated  $\text{H}_2\text{SO}_4$ . Standardize against monel metal of known manganese content. In the absence of such, excellent results may be obtained by standardizing against a Bureau of Standards high-manganese steel (1 g. sample) to which has been added 0.25 g. pure copper, and, if available, 0.75 g. pure nickel. Three per cent nitric acid is made by diluting 60 cc.  $\text{HNO}_3$  (1.42) to 2 liters.

#### NICKEL

Weigh 0.1 g. borings into 200 cc. beaker, dissolve in 10 cc.  $\text{HNO}_3$ , dilute to 50 cc. with hot  $\text{H}_2\text{O}$  and filter into 500 cc. beaker. Wash thoroughly with hot  $\text{H}_2\text{O}$  and dilute to 300 cc. Add 10 cc. tartaric acid solution and make faintly alkaline with  $\text{NH}_4\text{OH}$ . Heat to 80 to 85 deg. C., add 50 cc. glyoxime solution, and allow to stand in warm place 15 minutes. Filter by suction through Gooch (which has been previously dried in oven at 110 deg. C. for 45 minutes, cooled and weighed) and wash thoroughly with hot  $\text{H}_2\text{O}$ . Dry at 110 deg. C. for 45 minutes, cool and weigh.

$$\text{Per cent Ni} = \frac{\text{wt. ppt.} \times 20.31}{\text{wt. sample}}$$

The following precautions should be observed: An excess of  $\text{NH}_4\text{OH}$  is harmful in that the red precipitate of nickel dimethyl glyoxime is slightly soluble in  $\text{NH}_4\text{OH}$ . The proper degree of alkalinity may be easily recognized by the appearance of the first permanent shade of the familiar copper ammonium blue. The solution should just barely smell of  $\text{NH}_4\text{OH}$ . The best temperature for precipitation is 85 deg. C.

In preparing the tartaric acid solution dissolve 150 g. crystalline tartaric acid in 300 cc. hot  $\text{H}_2\text{O}$ , filter and dilute to 500 cc.; in preparing the glyoxime, add to 4 g. dimethyl glyoxime in small flask 100 cc. ethyl alcohol. Connect flask to return condensor or to long piece of glass tubing, and warm on steam bath until the salt dissolves. Dilute to 500 cc. with  $\text{C}_2\text{H}_5\text{OH}$ , and filter.

#### CARBON

Run direct combustion on 1.3636 g. borings by any of the common combustion methods.

Gain in weight of absorption apparatus  $\times 20$  = per cent carbon.

The method advocated is one devised by William R. Fleming, metallurgist and chief chemist, Andrews Steel Co., Newport, Ky., with a few changes. (See *Iron Age*, Jan. 1, 1914.) The essential principle of this combustion is the rapid passage of oxygen through the combustion train (325 cc. per minute) and the short time of combustion (5 minutes). The absorption bulb is a double chambered apparatus (Sargent bulb), a large chamber containing 20, 40 and 60 mesh soda lime of 2 per cent moisture packed in alternate layers, and a small chamber containing  $\text{P}_2\text{O}_5$ .

The writer has found that it is safe to increase the time of combustion, and actually uses 15 minutes for combustion, especially on high carbon steels and cast irons. The furnace should be at 1000 deg. C. preferably, but should not fall below 950 deg.

#### REPORTS ON FIVE ANALYSES

By running several determinations simultaneously, a monel metal may be analyzed with considerable accuracy in a few hours.

The following percentages were obtained by the above method.

	25.88	28.92	28.70	28.34	27.59
Cu	68.41	67.05	66.65	66.12	67.25
Fe	3.09	1.75	2.26	2.58	2.48
Al	0.32	0.27	0.20	0.42	0.03
Mn	2.09	1.74	2.04	2.28	2.27
C	0.25	0.27	0.26	0.24	0.38
Si	0.02	0.02	0.02	0.04	0.02
	100.06	100.02	100.13	100.02	100.02

#### Cleaning and Pickling Iron and Steel for Enameling Purposes

A paper on this subject by Mr. R. R. Danielson of the Bureau of Mines was drawn up for presentation at the meeting of the American Ceramic Society, Sept. 24, 1919, but arrived too late for the meeting. It deals with the several phases of cleaning discussed under the following heads:

- (a) Removal of grease.
- (b) Removal of oxides.
- (c) Neutralizing baths.
- (d) Drying of wares.

Under the subject of grease removal, a list of the various types of chemical grease removers is given and the procedure for using them on a commercial basis is taken up. The advantages and disadvantages of scaling and cleaning are discussed. Considerable part of the paper is devoted to the problem of pickling with the various acids. Special attention is given to the use of niter cake as a substitute for acids and data are presented on the use of this material in commercial work.

Under the head of neutralizing baths, the development of mottling of gray ware enamels is discussed. The composition of a prepared neutralizing agent is given and the results are compared with those obtained with the use of soda ash on metal prepared for ground coating. The object of the paper is to present general data from cleaning and pickling practice as a guide for investigative work on the various problems of these processes. The paper in full will be printed in the *Proceedings of the American Ceramic Society*.

The Civil Service Commission announces that open competitive examinations for laboratory assistant (men only) will be held Feb. 4-5 and March 3-4, 1920.

## Dangers in the Dyestuff Industry\*

**A Review of Incidental Accidents Due to Inexperience in New Industries, With Special Reference to the Dyestuff Industry—Explosion Risks of Dyes and Intermediates, of High Pressure Apparatus and of Inflammable Vapor Mixtures**

BY DR. L. C. CONE,  
National Aniline & Chemical Co., Buffalo, N. Y.

THE amount of danger in any industry is in inverse ratio to the knowledge and experience of the organization operating that industry. If a green crew, under the control of an inexperienced foreman, is employed in even so simple an operation as ice-cutting, there are bound to be accidents. The dyestuff industry of this country has been, in comparison with our older established industries, in the class of the above ice-cutting experiment. As a further complication added to inexperience has come the insistent demand for a large tonnage production of new products. These conditions have accentuated the dangers to such an extent that many serious accidents have resulted. Statistics gathered from our dyestuff and intermediates factories during the past five years would give a rather alarming picture of the risks of the business. There has been, however, on the part of the more stable companies engaged in the industry, no lack of appreciation of the nature of the risks involved. As a result of this appreciation of the dangers, constant progress is now being made in reducing the number and severity of accidents.

### INEXPERIENCE A SOURCE OF DANGER

Before we forget the hectic experience of the past five years some chemical genius, with a power of description and a keen sense of humor, should write the story of the war-time chemical development of this country. Many events in this development have the elements of sublimely ridiculous humor in them. One instance I have in mind where two college boys, without industrial experience, rented an old, abandoned, windowless brewery, with broken wooden floors, and a couple of rusty boilers. In this building they installed a makeshift aniline plant, and, in spite of every handicap, made aniline and sold it at a profit. It took American ingenuity and grit to make this plant go, and perhaps it also required American inexperience. An experienced aniline operator would have foreseen too many dangers to have ever started the project. Statistics of accidents from that and similar plants could hardly be considered the normal risk of our business. The proprietors themselves were always blue about the lips, and many a night they were just able to struggle home, get into a tub of warm water, drink a glass of milk, take a dose of salts, and go to bed. Is it not a wonder that, with the large number of such plants scattered all over the country, built by inexperience, and operated in spite of all hygienic laws, that the list of fatal accidents has not been greater? Gradually, however, we have been learning, partly by experience and partly by study, more about the risks of our business until today the hazards of the well-regulated dyestuff factory are little greater than the hazards of any mechanical plant containing a

large and varied assortment of moving machinery. The chemical risks of the industry are largely centered about the manufacture of intermediates. The dangers of aniline, nitrobenzol, dinitrobenzol, dinitrotoluol, etc., have been so frequently discussed, and the methods used by companies like our own for minimizing the risks of these manufactures so thoroughly described, that there is no need to go into this matter at this time.<sup>1</sup>

Our company has never suffered a fatality from any of these poisons, although we have had some very sick men. Under the conscientious watchfulness of Dr. Kessler, of our Marcus Hook plant, the number of such cases has become relatively small. I am certain that if any safety man desires further detailed information in regard to our methods of handling these cases, Dr. Kessler in response to an inquiry would be more than willing to acquaint him with our experience.

### PRACTICAL RESULTS OF SAFETY WORK

The experience of our Buffalo works is the most illuminating experience of any of our plants, because in that factory is concentrated practically every risk of the dyestuff industry. While we do not make aniline there, we handle enormous quantities of the product under a very wide variety of conditions. We make and use large quantities of dinitrobenzol, dinitrochlorbenzol, and other poisonous products. In the first six months of 1918, as shown in the table, our serious chemical accidents were 21 in number against 59 of a mechanical nature, or 26.2 per cent. The first six months of 1919 there were 13 severe chemical accidents against 36 severe mechanical accidents, or 26.5 per cent. These figures, taken from a report by Mr. Doepke, our safety engineer, show that even under the rather strenuous conditions of high production prevailing during these periods, and during the very unsatisfactory labor conditions of 1918, the mechanical accidents far surpassed the chemical accidents. A closer analysis of the accident chart herewith will show that the majority of these accidents are of the preventable type. Acid burns, alkali burns, fume poisoning and eye accidents can, by education and constant watchfulness, be avoided, or at least reduced to a very low point.

### EXPLOSION RISKS

Omitting further discussion in regard to these ordinary causes of chemical accidents, I wish to call attention to what I consider to be the greatest hazard of the dyestuff industry today, at least from the standpoint of severity of results. This is the explosion risk. From this cause alone we suffered three fatalities in 1918. These fatalities occurred in one instance where a considerable quantity of explosive dye ignited and killed three men. Records of the dyestuff industry,

\*Read at the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, October, 1919.

<sup>1</sup>J. Ind. Eng. Chem., vol. 8, pp. 573, 1161; (1916).

during the last two or three years especially, have been full of reports of similar accidents at other plants. The disastrous fire at the plant of the Atlantic Dyestuff Co. in Nyack, N. Y., was caused by an explosion. According to the Sept. 1 issue of the *Journal of Industrial and Engineering Chemistry* (p. 893), there was recently another serious dyestuff explosion in Boston, Mass. Practically every dyestuff company in the country has had more or less experience along the same lines. This is a hazard which chemists and safety men must inform themselves about and which they must guard against more carefully. The greatest risks of explosions about dyestuff plants are three in number: Explosions of dyes and intermediates, explosions of pressure kettles, and explosions of vapors mixed with air.

## EXPLOSION OF DYES

The type of explosion which has caused our greatest loss is the explosion of dyes themselves. We have been prone to forget that dyes are organic compounds, some of them closely related to explosives. We have not accustomed ourselves to consider each new dye as a possible explosive, but have gone ahead, powdering and grinding our products in blissful ignorance until an accident has called our attention to the danger. A dye widely used for khaki shades on wool during the war was known as chrome yellow. This was made in very large quantities, dried, ground, packed, and shipped. It is doubtful if a single producer of this dye tested this material for its explosive properties before he began to produce it on a commercial scale, yet, as I can quickly demonstrate to you, by igniting a small portion of the dye, its quick burning properties render it more dangerous than many of our violent explosives. It is further doubtful if a single producer of this dye escaped the penalties of his failure to test the product. One large producer informed me that the total profits from his

company's manufacture of this dye had been lost through disastrous fires and accidents. The same thing is true of another widely used chrome dye, which is frequently known as metachrome brown. This product has been the cause of at least three disastrous explosions in different companies to my own knowledge. With these experiences in mind we shall be very remiss in our duties if we do not examine every new dye for its explosive properties. A general rule, well known to chemists who have dealt with explosives, indicates what classes of dyes are apt to develop explosive characteristics. This rule may be summed up very roughly as follows: "Be extremely critical toward dyes which are to be handled in the form of dry powders unless they are well supplied with sulphonic acid groups."

Even after the dye is given a clean bill of health by the chemist because of its composition, it would not be remiss to have the dye tested before drying and powdering. This is a service which the dye producers owe to their consumers as well as to their employees, for many dyes are mixed in mills and exposed to conditions which might produce explosions.

## EXPLOSION OF HIGH PRESSURE APPARATUS

With this danger of dye explosion eliminated, the next explosion risk which the chemical industry faces is that of pressure kettles. Chemistry at high pressure has only begun its development in this country. Processes which have normally been considered impossible are gradually being carried out under conditions of high pressure. The best illustration of this is the Haber synthesis of ammonia from nitrogen and hydrogen. This reaction will not take place between the two gases under atmospheric pressure, but when the two gases are brought together at very high pressure in the presence of a catalyst at elevated temperature, the two unite to a certain extent to form

COMPARATIVE ACCIDENT REPORT, 1918-1919—FREQUENCY AND SEVERITY

COMPARATIVE ACCIDENT REPORT, 1918-1919—FREQUENCY AND SEVERITY										
1918			January-July				1919			
No. Accidents Time Lost	No. Days Lost	No. Minor Accidents	Per Cent Frequency	Per Cent Severity	Nature of Accident	No. Accidents Time Lost	No. Days Lost	No. Minor Accidents	Per Cent Frequency	Per Cent Severity
52	321	268	71.11	15.05	A. Non-Chemical Injuries	35	361	165	73.26	38.16
1	29	16	3.78	1.36	1. Traumatic Lesions—Head, Trunk, Extremities	...	...	13	4.76	....
3	8	8	2.44	0.38	2. Burns	...	...	11	4.03	....
1	13	3	0.89	0.60	Steam and Water	...	...	...	...	...
					Hot Liquids	...	...	...	...	...
					Flames	...	...	...	...	...
2	33	9	2.44	1.55	3. Electrocutions	1*	360	...	0.37	38.06
					4. Eye Accidents — Grinding, Chips, etc.	...	...	1	0.37	....
59	404	304	80.66	18.94		36	721	190	82.79	76.27
1	3	20	4.67	0.14	B. Chemical Injuries					
..	..	16	3.56	....	1. Acid Burns	1	48	7	2.93	5.08
					2. Alkali Burns	1	2	10	4.03	0.21
3*	1605	....	0.67	75.25	3. Explosion Burns	...	...	...	...	...
3	11	2	1.11	0.51	4. Fumes	...	...	...	...	...
5	17	1	1.33	0.80	Nitrous—Sundries	...	...	1	0.37	....
1	8	...	0.22	2.38	Nitrochlorbenzol	6	64	1	2.56	6.77
					Nitrobenzol	...	...	...	...	...
1	4	...	0.22	0.19	Meta-Phenylenediamine	1	2	...	0.37	0.21
1	55	...	0.22	2.58	Dinitrobenzol	2	12	...	0.73	1.26
2	15	2	0.89	0.70	Aqua Ammonia	...	...	...	...	...
					Hydrogen Sulphide ( $H_2S$ )	2	97	...	0.73	10.25
					5. Aniline Poisoning—Fumes and Absorption	...	...	...	...	...
2	6	15	3.78	0.28	6. Eye Accidents					
2	5	10	2.67	0.23	Acids—Colors	...	...	8	2.93	....
21	1729	66	19.34	81.06	Alkalies	...	...	7	2.56	....
Total Non-Chemical			80.66	18.94					82.79	76.22
Total Chemical			19.34	81.06					17.21	23.78
Grand Total			100.00	100.00	(3 deaths)					(1 death)

\* Fatal Accidents—Customary charge for each case of death—360 days.

ammonia. With the growth of our American chemical industry, reactions of this type will be more and more largely introduced into our manufacturing plants. As they are introduced, the explosion hazard will become greater and greater, and the safety men must co-operate closely with the technical engineers to see that every possible precaution is taken against disastrous results to our workmen and to our plants. It has been rumored that the very important intermediate, paranitraniline, has been made commercially by only one process in this country because another process, which offers many advantages, has a great explosion risk connected with it owing to very high pressure. If the American dyestuff industry is to be permanently successful, it must not permit itself to be restrained because of high pressure explosion risks. The control of this risk is primarily of course a technical engineering problem, but after the engineering lay-out is complete the safety man will find his opportunity to provide such appliances and such conditions as will give minimum destruction to life and property in case the engineering equipment ever fails.

#### EXPLOSION OF INFLAMMABLE VAPOR MIXTURES

The risks of explosion due to the ignition of mixtures and combustible vapors with air are already thoroughly appreciated by the technical and safety men. I only wish to call attention to the fundamental principles which must be followed in safety precautions to avoid explosions of this kind. While every effort to keep flames away from inflammable mixtures is commendable, these precautions alone will never entirely prevent ignition of explosive mixtures. Every effort must be concentrated on preventing the formation of such mixtures. Many disastrous explosions have occurred where every precaution has been taken to avoid the presence of all sources of fire. It is never possible to entirely do away with the chance formation of either frictional or electrical sparks. These are apt to be formed at most unexpected times, and at these times, if an explosive mixture of air and vapor is present, an unexplained disaster results. One of the most disastrous explosions I have ever witnessed, in which a large and well equipped plant was completely destroyed, was due to a chance frictional spark.

#### STATIC DISCHARGES MUST BE GUARDED AGAINST

As an illustration of the extreme difficulty of preventing ignition by chance sparks I will cite a case of my own observation where a large amount of toluene was stored in a glass enameled steel tank. It never occurred to the operators that a glass enameled steel tank is an ideal electrical condenser. The contents of the tank were not grounded in any way. A leak of toluene from the bottom valve soaked the floor under the tank; the workman, in attempting to repair this leak, made connection between the contents of the tank and the floor through a wire in his hand; the toluene on the floor immediately became ignited. Quick-witted workmen threw a few shovels of snow, which happened to be convenient, over the burning toluene and succeeded in smothering the flame before it ignited the tank.

For handling problems of this kind the safety engineer must have a very clear appreciation of the fundamental principles of both physics and chemistry, and must further work in close touch with the technical men of his own organization. By such close co-operation and careful study of each accident that occurs it will be gradually possible to eliminate the explosion risks of our industry.

## Legal Notes

### Exclusive License of a Patented Chemical Process Not a Sale of Business in a Foreign Country

BY WELLINGTON GUSTIN

THE distinction between the "sale" of a chemical company's foreign business and its contract to license the manufacture and sale of its products under the patents held by it in a foreign country was recently decided by the Supreme Court of Massachusetts (Arnold vs. North American Chemical Co., 122 N. E., 283). The inventor of a patented shoe "filler" brought suit against the defendant chemical company to recover his part of the proceeds of what he claimed was a sale of its foreign business.

Referring to the facts, it appears that the defendant chemical company, in a written contract with the plaintiff, agreed "that if it ever sells the filler business for Canada or for any foreign country," it would pay him a proportionate part thereof. The question for determination was whether the defendant had become liable under this clause of the contract.

The "filler business" was the right to manufacture and sell a certain trade-named shoe filler, a patented article used in the manufacture of shoes.

#### TERMS OF THE CONTRACT

After entering into the contract as stated above, the defendant chemical company made a contract whereby it granted to a British corporation, which theretofore had been its sole agent to sell this patented product in England, "an exclusive license under the patents in the territories of Great Britain and Germany to manufacture, use, exercise and sell this shoe filler from 1908 to August, 1919, subject to the further terms and conditions of the agreement, with right to assign the license or to grant sub-licenses therefor." Other terms and conditions followed as to the furnishing to the defendant by the British corporation of patterns of "outfits" and of the chemical compound required for the manufacture.

At the end of five years either party might terminate this part of the contract by one month's notice, whereupon the defendant was to furnish the British licensee with the formula by which to make the compound and further instructions as to its preparation, if necessary under some restrictions as to time. The payment to the defendant for these rights was a gross sum in several installments. In this connection it was stipulated that in the event the defendant should default for 21 days in furnishing the chemical compound required by the British licensee, the latter would have the option either to demand the formula with which the compound was made, with instructions as to its preparation, or to require a refund of all payments made to the defendant under the contract.

It was further provided that in case the British licensee should bring suit against any infringer of the patents before 1910 the defendant would bear half the court costs, lawyers' fees, etc. The defendant agreed to make no sales of the filler except for its American trade, and agreed also to pay one-half the British income tax in five annual payments.

In 1914 a supplemental agreement was entered into extending the term of the license for a further term of five years on six months' notice to the defendant.

This they called a "license extension." It was recited that the British corporation desired to discontinue its obligations as to Germany, and the defendant thereafter was to relieve it from paying German taxes and was to have the privilege of selling the product in Germany, Australia and South America. Defendant was to continue to supply the British corporation the compound for the manufacture of the filler on stipulated terms.

#### WAS THE CONTRACT A SALE?

Since the plaintiff sued to recover under his contract with defendant, claiming a sale of the filler business for Canada and other foreign countries by the latter, the point decided by the court was whether these two contracts between the British licensee and defendant constituted a sale of its business in a foreign country.

There was no evidence introduced showing the patent laws of either England or Germany touching the sale or assignment of patent rights that might limit these contracts, therefore the court held that the words of the contracts and the acts of the parties were to be construed according to the common law principles prevailing in the State where the contract was made.

#### DEFINITION OF A SALE

The court defined a sale to be "the transfer of property from one person to another for a consideration of value." The word "sale," it said, had a well-defined meaning. It implies the passing from the seller to the buyer of the general and absolute title to property as distinguished from a special interest, a bailment, a license, a lease, a pawn, or other limited right falling short of complete ownership. Therefore it is plain that the contract between the defendant and the British corporation in form was not a sale. They called it an "exclusive license." Those terms imply a privilege or authority granted to another by one who possesses and retains a superior right or power. Applied to a patent it signifies the assignment by the patentee to another of rights less in degree than an interest in the patent itself. The law, however, will not be bound by the form of the transaction, but will look to the interest of the parties, considering all the words used, in order to determine whether there has been a sale.

#### COURT HOLDS THIS WAS A LICENSE, NOT AN ABSOLUTE TRANSFER

From this test the contract confers a license and is not the equivalent of a sale or absolute transfer. It was limited in point of time, for the period during which the British corporation had rights under the patents was definitely restricted, and well may have been less than for the term for which the patents were issued in England and Germany, as the unexpired term of these patent rights did not appear in the record.

Referring back to the terms and stipulations of the two contracts with the British corporation, they will be seen to impose restrictions and limitations and conditions such that the combined effect of these clauses demonstrates that the entire title to the patents in Great Britain was not transferred to the British corporation, and hence they did not amount to a sale. The obligation on the defendant to pay part of the expenses of litigation for infringement and to bear a part of the income tax, and the retention by the defendant of the formula of the compound show a retention

of an interest, however small, in the British and other patents.

The other conditions which have been enumerated are confirmatory of an intention, as expressed in the contract, by the defendant not to sell and by the British company not to buy the "filler business." Without the aid of the defendant the plaintiff could not use the patent monopoly business in Great Britain.

Therefore, the court ruled, the effect of the written instruments was to grant a license and not to make a complete transfer, and judgment for defendant was affirmed.

#### Measure of Damages for Failure to Deliver Acid Under Contract

In an action founded upon a breach of contract a writ of attachment was quashed by the court for the reason that the damages for the breach were unliquidated. (T. J. Parker, Inc., vs. Anthony Hammond Chemical Works, 107 A., 44.) The plaintiff appealed from this order of the trial court to the Supreme Court of New Jersey.

From the plaintiff's case it appears that it entered into a contract with the defendant for the sale and delivery of 2,000 lb. of benzoic acid at \$2 a lb., the delivery to be made in parcels of 500 lb. each and to begin in the first week of December, 1917, and to continue thereafter each week until the delivery was complete. The defendant failed to perform the contract, and plaintiff sought to recover the damages sustained by it by reason of this failure of performance and obtain its writ of attachment against the defendant.

#### DISTINCTION BETWEEN LIQUIDATED AND UNLIQUIDATED DAMAGES

The court said that on its face this was an action for unliquidated damages for which an attachment should not be granted. But plaintiff's claim to sustain its writ was that the damages are liquidated, in that after the breach of contract it went into the market and purchased 2,000 lb. of benzoic acid at \$4.75 per lb., the damages being definite and ascertainable by mere computation, the sum due being the difference between the contract price of \$2 and the purchase price of \$4.75.

However, the purchase by plaintiff was not made until more than a month after the time for the completion of the delivery under the contract had elapsed. Hence, the court said, this claim of plaintiff rested on an unsound basis. Ordinarily the difference between the contract price and the value of the goods at the date fixed for delivery is the measure of damages. In this case, whether the price paid was the fair market value of the acid at the time fixed for its delivery and whether the acid which was actually purchased was of the same character and value as that contracted for are questions to be determined by the jury and upon its determination the amount of the recovery would depend.

What the jury might determine is uncertain, and where the amount of the recovery depends on the finding of the jury upon these points the damages are, of course, unliquidated. Therefore the court held that a claim for damages for failure to deliver goods in pursuance of an executory contract of sale is a claim for unliquidated damages, and plaintiff's writ of attachment was quashed.

## Copper-Aluminum-Iron Bronze as an Acid-Resisting Alloy

BY O. L. KOWALKE

ALTHOUGH much has been written concerning copper-aluminum-iron bronze for bearings, gears, etc., in machinery, there does not appear to be much data available on its acid-resisting properties. In tensile strength and ductility it ranks with mild steel; it can be easily machined to a nice finish; it can be forged while hot and also rolled into sheets. Sound castings of a wide range in size can be made of it free from shrinkage-holes or blow-holes.

A number of other alloys have been studied in the University of Wisconsin laboratories for their acid-resisting properties, but most of them were rather weak mechanically. The satisfactory mechanical properties of copper-aluminum-iron bronze prompted a study of the resistance to corrosion in acids and alkalis. Commercial bronzes were preferred over those made in the laboratory. Through the courtesy of the American Metal Products Co., Milwaukee, Wisconsin, several commercial bronzes were obtained for these tests, but the results on two only, Bronzes A and B, whose average compositions and properties are given below, will be reported here.

Composition:	Bronze A	Bronze B
Copper.....	87.0 per cent	85.6 per cent
Aluminum.....	9.8 per cent	10.81 per cent
Iron alloy.....	3.14 per cent	3.57 per cent
Ultimate unit stress.....	74,800 lb. sq.in.	66,600 lb. sq.in.
Per cent reduction in area.....	19.0 per cent	13.0 per cent
Per cent elongation in 2 inches.....	21.0 per cent	11.5 per cent
Specific gravity.....	7.71	7.58

The specimens for the corrosion tests were practically uniform in size, having dimensions approximately 1 in. long by 0.07 in. wide by 0.07 in. thick, were finished smooth, and had square edges. Each specimen was stamped to identify it for composition and serial number, and its total surface was measured so as to determine the corrosion per square inch.

Most of the corrosion tests were made at room temperatures, 72 deg. F. and 85 deg. F.; a few tests were made at 194 deg. F. The regular "C.P." acids of the laboratory were used and made up to strengths desired by titration methods. For the tests at room temperatures the various acids were put into covered beakers in amounts of 200 cc. Two specimens of bronze were set on edge in each beaker in such manner that all the surface was exposed to acid and that they did not touch each other. The specimens were removed periodically, washed in water, dried thoroughly, and then weighed on an analytical balance. The combined loss in weight of both specimens was then computed as loss per square inch. For the corrosion tests at higher temperatures wide-mouthed flasks were provided with rubber stoppers through which were inserted glass tubes 3 ft. long, open at both ends, to serve as condensers. An electrically heated oven kept the flasks and contents at an average temperature of 194 deg. F. In other respects the procedure was identical with that at room temperature. The results of the tests are given in Tables I and II for Bronzes A and B respectively.

It will be noted in Table I that Bronze A is resistant to several acids and particularly to sulphuric, lactic, phosphoric, tartaric, and acetic. Nitric acid attacks the metal readily, the concentrated acid acting violently. Hydrochloric acid and aqua ammonia both attack the metal too readily for commercial purposes. Caustic soda

makes but little inroad on this metal either hot or cold; the slight gain during corrosion at 194 deg. F. is due to the formation of a film that was difficult to remove by rubbing with a cloth.

Table II gives the results for Bronze B, and the striking fact is the resistance to corrosion in sulphuric acid. By increasing the aluminum in this metal 1 per cent, the iron alloy about  $\frac{1}{2}$  per cent over the proportions in Bronze A, the resistance to corrosion is materially increased, even though the average temperature was 13 deg. F. higher. Nitric acid also attacks Bronze B too rapidly; hydrochloric acid attacks it more readily than Bronze A. Ammonia does not corrode this metal so readily as Bronze A.

TABLE I—BRONZE A  
Cumulative Loss in Grams per Square Inch  
Sulphuric Acid

Days	Temperature, 72 Deg. F.			Temperature, 194 Deg. F. 35 per Cent
	50 per Cent	35 per Cent	10 per Cent	
7	0.0125	0.0033	0.0090	0.0094
14	0.0167	0.0075	0.0178	0.0624
21	0.0212	0.0131	0.0278	0.2016
28	0.0246	0.0177	0.0365	0.2520
Hydrochloric Acid				
7	0.0484	0.117	.....	.....
14	0.2010	0.924	.....	.....
21	0.781	1.73	.....	.....
28	.....	1.90	.....	.....
Ammonia				
7	0.130	0.185	0.112	.....
14	0.350	0.435	0.194	.....
21	0.531	0.640	0.413	.....
28	0.700	0.850	.....	.....
Caustic Soda				
7	0.0005	0.0006	0.0010	*0.0014
14	0.0006	0.0006	0.0024	*0.0014
21	0.0008	0.0013	0.0036	*0.0021
28	0.0007	0.0016	0.0055	*0.0020
Lactic Acid				
7	0.0025	0.0031	0.0031	0.0130
14	0.0051	0.0062	0.0077	0.0538
21	0.0082	0.0097	0.0126	0.0980
28	0.0111	0.0132	0.0168	0.1550
Phosphoric Acid				
7	0.0025	0.0040	0.0056	0.0002
14	0.0046	0.0078	0.0113	0.0004
21	0.0081	0.0132	0.0197	0.0083
28	0.0114	0.0181	0.0281	0.0395
Tartaric Acid				
7	0.0009	0.0015	0.0026	0.0013
14	0.0014	0.0025	0.0044	0.0029
21	0.0022	0.0037	0.0061	0.0099
28	0.0028	0.0046	0.0077	0.0155
Acetic Acid				
7	0.0081	0.0076	0.0046	0.0026
14	0.0170	0.0139	0.0092	0.0083
21	0.0299	0.0243	0.0173	0.0398
28	0.0386	0.0312	0.0221	0.0713

\* Gain.

TABLE II—BRONZE B  
Cumulative Loss in Grams per Square Inch  
Sulphuric Acid

Days	Temperature 85 Deg. F.			10 per Cent
	50 per Cent	35 per Cent	10 per Cent	
7	0.0016	0.0020	0.0056	
14	0.0016	0.0029	0.0072	
21	0.0018	0.0035	0.0095	
28	0.0024	0.0044	0.0120	
35	0.0025	0.0049	0.0145	
Acetic Acid				
7	0.0156	0.0087	0.0076	
14	0.0300	0.0183	0.0154	
21	0.0492	0.0302	0.0256	
28	0.0689	0.0442	0.0334	
35	0.1001	0.0559	0.0447	
Ammonia				
7	0.0144	0.0302	0.0868	
14	0.1376	0.1993	0.2087	
21	0.2733	0.2806	0.2237	
28	0.3810	0.3406	0.072	
35	.....	0.3791	.....	
Caustic Soda				
7	.....	0.0015	0.0026	
14	.....	0.0016	0.0045	
21	.....	0.0019	0.0059	
28	.....	0.0022	0.0072	
35	.....	0.0023	0.0078	

It is interesting to note from the results below that the corrosion in 35 per cent sulphuric acid of a forged specimen of Bronze A is only about one-half that of the rolled sheet and cast varieties.

#### CORROSION OF FORGED, ROLLED SHEET, AND CAST BRONZE A IN SULPHURIC ACID 35 PER CENT.

Cumulative Loss in Grams per Square Inch at 72 Deg. F.

Days	Forged	Rolled Sheet	Cast
7	0.0014	0.0034	0.0033
14	0.0028	0.0066	0.0068
21	0.0041	0.0113	0.0111
28	0.0055	0.0136	0.0144

Chemical Engineering Laboratory,  
University of Wisconsin,  
Madison, Wis.

## Cost of Copper in 1918

IN submitting a report on the cost of producing copper for 1918, covering 85 companies, 95.5 per cent of the United States production, the Federal Trade Commission remarks that the reduction of prices by the Government did not hinder the maximum production nor prevent the very high earnings of copper companies. Table I shows the relation between production and prices, and despite the forced reduction in price by quarters in 1917 from 33.7c. to 32.4c., to 27.2c. and to 23.5c. per lb., production was practically stationary.

TABLE I. RELATION BETWEEN PRODUCTION AND PRICES

Year	Production, Lb.	= %	Price in New York & Electrolytic, Cents
1913	1,224,484,098		15.5
1914	1,150,137,192	-6.07	13.3
1915	1,388,009,527	+20.68	17.5
1916	1,927,850,548	+38.89	28.5
1917	1,886,120,721	-2.16	29.2
1918	1,908,533,595	+1.19	24.7

\* U. S. Geological Survey.

† War Industries Board.

Again, on an aggregate investment of \$672,000,000 it seems that about 30 cents investment is required to produce a pound of copper yearly. The profit per pound is shown by Table II to be 8.34c., or at an actual average rate of 28 per cent.

As a matter of fact 6 porphyries producing 570 million pounds netted 41.84 per cent; 6 lake companies producing 100 million pounds netted 46.97 per cent, and 6 other companies producing 424 million pounds netted

TABLE II. COST AND PROFITS PER POUND OF COPPER AND RATE OF RETURN ON INVESTMENT FOR "PORPHYRY," "LAKE" AND OTHER COMPANIES, BY COST GROUPS, FOR THE YEAR 1918

No. of Com- pa- nies	Per Cent of Produc- tion	Weighted Average Cost, Cents	Average Selling Price, Cents	Profit per Pound, Cents	Invest- ment per Pound, Cents	Per Cent of Return on Inves- ment
Porphyry 11	778,360,356	34.47	14.886	24.672	9.786	28.803
Other.... 53	1,253,767,585	55.52	16.700	24.388	7.688	29.779
Lake..... 21	226,106,184	10.01	17.622	24.637	7.015	33.000
Total and average 85	2,258,234,125	100.0	16.167	24.511	8.344	29.765
						28.03

52.29 per cent. Another view of the matter is to be had from Table III, which shows that nearly half of the copper was produced for less than 16c., (and sold at 24.6c.), while 85 per cent of the production cost less than 20c.

TABLE III. QUANTITIES OF COPPER PRODUCED IN 1918 AT DIFFERENT RATES OF COST PER POUND

Item	No. of Com- pa- nies	Production, 1918	Per Cent of Total	Accum- ulated, per Cent
Cost less than 12 cents.....	2	122,245,051	5.41	5.41
Cost between 12 and 13 cents..	4	208,571,191	9.24	14.65
Cost between 13 and 14 cents..	4	314,553,177	13.93	28.58
Cost between 14 and 15 cents..	4	359,617,743	15.92	44.50
Cost between 15 and 16 cents..	2	98,307,293	4.35	48.85
Cost between 16 and 17 cents..	8	460,528,645	20.39	69.24
Cost between 17 and 18 cents..	9	255,399,696	11.32	80.56
Cost between 18 and 19 cents..	3	72,373,388	3.20	83.76
Cost between 19 and 20 cents..	5	28,491,436	1.26	85.02
Cost between 20 and 21 cents..	5	36,871,193	1.63	86.65
Cost between 21 and 22 cents..	9	135,538,602	6.00	92.65
Cost between 22 and 23 cents..	3	60,861,465	2.70	95.34
Cost between 23 and 24 cents..	5	44,919,772	1.99	97.32
Cost between 24 and 25 cents..	1	6,230,694	0.28	97.66
Cost between 25 and 26 cents..	3	7,605,224	0.34	97.90
Cost over 26 cents.....	18	46,119,555	2.04	100.00
Total all companies reporting 85		2,258,234,125	100.0	.....
Approximate pounds duplicated ..		63,700,000	.....	.....

For the purposes of the Commission the term "cost per pound" is the cost of a pound of marketable copper at the Atlantic seaboard, including all items of labor, material, supplies, overhead, depletion and depreciation, but does not include interest, or income or excess profits taxes. Precious metals and by-products are credited. Production was reckoned by the quantity of copper in ore or concentrate, less smelted deductions, or by the smelter output.

TABLE IV. AVERAGE COST OF PRODUCTION OF COPPER BY OPERATIONS AND BY GEOGRAPHICAL DIVISIONS, AND PERCENTAGE OF EACH ITEM OF COST TO TOTAL, FOR THE YEAR 1918

Operation	Weighted Average Costs							All Com- pa- nies Report- ing
	Arizona and New Mexico	Utah and California	Idaho and Washington	Michigan	United States	Mexico, Cuba and South America	Canada and Alaska	
Pounds produced.....	863,493,944*	350,323,659†	331,624,111‡	226,106,184	15,838,808	350,764,079	120,093,340	2,258,234,125
Mining.....	\$0.05615	\$0.04277	\$0.10858	\$0.10693	\$0.06403	\$0.05532	\$0.06198	\$0.06946
Depletion of ore at cost.....	.00627	.00528	.01225	.00508	.00385	.00718	.00999	.00720
Purchases of ore.....	.01056	.00649	.01613	.....	.00403	.00053	.....	.00515
Transportation to reduction plant.....	.00648	.01731	.00436	.00748	.00656	.00491	.01903	.00837
Reduction.....	.05278	.07800	.05165	.04551	.10988	.06939	.05523	.05891
Transportation to refinery or seaboard.....	.00728	.00743	.00722	.00416	.00500	.01782	.00620	.00854
Refining.....	.01183	.01272	.01211	.00114	.01106	.00692	.01398	.01029
General and administrative.....	.00899	.00892	.00432	.00742	.01730	.01373	.01007	.00899
Selling expense.....	.00189	.00169	.00025	.00061	.00194	.00421	.00241	.00188
Credit for precious metals.....	.01048	.01260	.04262	.02011	.02455	.02353	.01626	.01712
Total cost.....	\$0.15175	\$0.16801	\$0.17425	\$0.17622	\$0.19910	\$0.15648	\$0.16263	\$0.16167
Labor.....	\$0.04424	\$0.04464	\$0.09473	\$0.07832	\$0.06995	\$0.02915	\$0.04611	\$0.05307
Materials and supplies.....	.03242	.04119	.04296	.05050	.06536	.03031	.04386	.03764
Overhead.....	.01851	.01428	.01784	.01096	.04907	.04826	.01117	.02145
Depreciation.....	.00686	.00692	.01170	.01261	.01299	.01207	.01520	.00945
Depletion.....	.00627	.00528	.01225	.00508	.00385	.00718	.00999	.00720
Tolls.....	.05393	.06830	.03739	.02086	.02243	.05305	.05256	.04998
Credits.....	.01048	.01260	.04262	.06211	.02455	.02354	.01626	.01712
Total.....	\$0.15175	\$0.16801	\$0.17425	\$0.17622	\$0.19910	\$0.15648	\$0.16263	\$0.16167

\* Approximate duplication 23,500,000 lb.

† Approximate duplication 4,400,000 lb.

‡ Approximate duplication 35,800,000 lb.

TABLE V. COMPARATIVE COSTS OF PRODUCING COPPER BY OPERATIONS OF FIVE GROUPS OF REPRESENTATIVE COMPANIES FOR THE YEAR 1918

Operations	(a) Group 1	(b) Group 2	(c) Group 3	(d) Group 4	(e) Group 5	(f) Group 6
Production, 1918 (pounds) .....	54,302,538	504,728,617	156,341,715	183,521,467	320,913,109	217,055,154
Mining, including depletion .....	\$0.14644	\$0.04174	\$0.06747	\$0.08009	\$0.07485	\$0.05465
Purchased ore .....			.00030	.01142	.01349	
Transportation to reduction plant .....	.00845	.01183	.01828	.00810	.00483	.00296
Reduction .....	.04939	.06135	.03861	.07430	.05043	.07426
Transportation to refinery .....	.00694	.00662	.00659	.00716	.00944	.01063
Refining .....	.01800	.01200	.00992	.01079	.01126	.00330
General and administrative .....	.00657	.00823	.00927	.01181	.00914	.00765
Selling .....	.00149	.00159	.00208	.00214	.00199	.00358
Credits .....	.03436	.00366	.00974	.01428	.03590	.00110
Net total .....	\$0.20292	\$0.13970	\$0.14278	\$0.19153	\$0.13953	\$0.15593
Labor .....	\$0.09188	\$0.03501	\$0.03795	\$0.06992	\$0.04046	\$0.03850
Materials and supplies .....	.03413	.03060	.02448	.05337	.03114	.04082
Overhead .....	.01678	.01538	.02256	.01669	.02338	.03935
Depreciation .....	.00167	.00636	.00726	.01030	.00537	.01703
Depletion .....	.00984	.00285	.00893	.00593	.00879	.00253
Tolls .....	.08298	.05316	.05134	.04919	.06629	.01880
Credits .....	.03436	.00366	.00974	.01427	.03590	.00110
Net total .....	\$0.20292	\$0.13970	\$0.14278	\$0.19153	\$0.13953	\$0.15593

(a) Operate mine only, balance of operations are toll.  
 (b) "Porphyries" companies operate mine and mill, balance of operations are toll.  
 (c) Operate underground mine and mill, balance of operations are toll.  
 (d) Operate mine, mill, and smelter, balance of operations are toll.  
 (e) Operate mine and smelter, balance of operations are toll.  
 (f) These companies operate mine, mill, smelter, and refinery, toll paid for transportation only.

TABLE VI. COMPARISON OF THE COST OF PRODUCTION OF COPPER AND QUANTITY OF OUTPUT, BY GROUPS, FOR THE YEAR 1918

	Number of Companies	Production	Per Cent of Production	Accumulative per Cent of Production	Cost per Pound
<b>Companies other than porphyries and lake:</b>					
Producing up to 1,000,000 pounds .....	5	3,663,715	0.29	0.29	\$0.28300
Producing 1,000,000 to 5,000,000 pounds .....	15	35,762,536	2.85	3.14	.26652
Producing 5,000,000 to 10,000,000 pounds .....	13	98,305,383	7.84	10.98	.21109
Producing 10,000,000 to 25,000,000 pounds .....	7	119,151,794	9.50	20.48	.21256
Producing 25,000,000 to 50,000,000 pounds .....	4	162,862,598	12.99	33.47	.18581
Producing 50,000,000 to 75,000,000 pounds .....	5	297,468,241	23.73	57.20	* .13180
Producing over 75,000,000 pounds .....	4	536,553,318	42.80	100.00	.15519
Total .....	53	1,253,767,585	100.00	.....	\$0.16700
<b>Lake</b>					
Producing up to 2,000,000 pounds .....	5	6,976,960	3.09	3.09	\$0.34614
Producing 2,000,000 to 5,000,000 pounds .....	6	19,648,056	11.78	11.78	.22691
Producing 5,000,000 to 11,000,000 pounds .....	4	33,601,942	14.86	26.64	.16187
Producing over 11,000,000 pounds .....	6	165,879,226	73.36	100.00	.16579
Total .....	21	226,106,184	100.00	.....	\$0.17622
<b>Porphyry</b>					
Producing 15,000,000 to 50,000,000 pounds .....	4	94,888,019	12.19	12.19	\$0.17924
Producing 50,000,000 to 98,000,000 pounds .....	4	294,703,233	37.86	50.05	.15575
Producing over 98,000,000 pounds .....	3	388,769,104	49.95	100.00	.13623
Total .....	11	778,360,356	100.00	.....	\$0.14886

\* Due to one company having a very low cost on account of the ore assaying close to three times as great as that of any other.

Costs were calculated on as near a uniform basis as possible, according to forms shown in blank in the report. The principal item of difference is in the calculation of the charge for depletion of the ore body. Two viewpoints stand out clearly in respect to the method of calculation and purposes of such a charge. For convenience they may be designated: (1) The cost viewpoint and (2) the tax viewpoint. The Commission has used the cost viewpoint in all reports, which makes an average difference of over 2c. per lb. and in individual cases as much as 5c. per lb. from that claimed by the companies.

The method of calculation used by the Commission is as follows: The actual cost of the mineral lands divided by the tons of ore in reserve plus the tons of ore mined gives the depletion cost per ton. To reduce it to depletion per pound, this result is divided by the recoverable pounds of copper in a ton of ore. The difficulties, of course, are to determine (1) the actual cost of the mineral land; and (2) the quantity of ore in the ground.

"Up to the year 1917," quoting the Commission, "few companies reported depletion as a cost; whereas practically all companies now include such a charge based on the revaluation of their mineral land. This is one of the largest single factors accounting for the apparently

large increase in the cost of producing copper in the last year or two."

Table IV shows for the year 1918 the average costs of production by operations and by geographical divisions, giving the costs per lb. and the percentages of each item of cost, together with the same costs itemized by the elements of expense.

Items of note in Table IV are the relative low costs from Arizona and New Mexico, where most of the porphyries, as well as some high-grade mines, are located. Excessive values for depletion due to inflated land values may be noted in Montana, while the figure for mining reflects the fact that deep mines and high labor rates are the rule. Michigan mines from very deep levels, but the industry exists by reason of low smelting and refining costs as well as smaller transportation and other tolls. Abnormally low labor costs in Latin America are counterbalanced by the overhead.

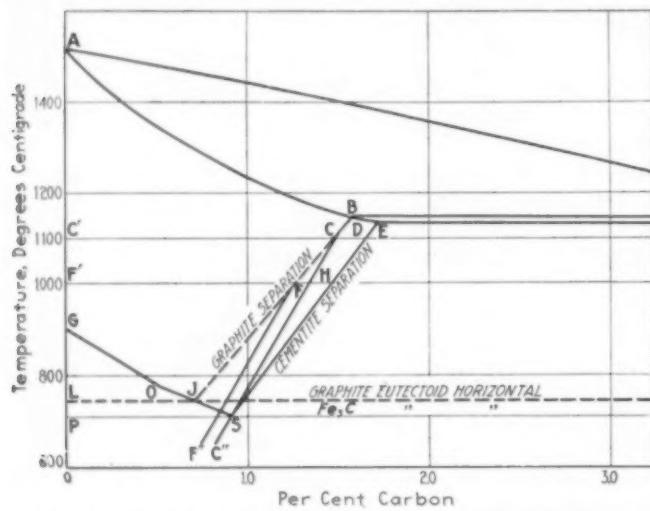
Reclassification according to nature of operations, as in Table V, also gives interesting materials for comparison.

Another interesting factor affecting the cost of production is the quantity of output. Table VI is a statement showing that large producers generally produced copper at a lower cost than the small ones.

## Synopsis of Recent Chemical and Metallurgical Literature

**Graphitization of White Cast Iron.**—A study of certain phases of chilled-iron car wheel manufacture was made by Dr. MERICA and L. J. GUREVICH, of the Bureau of Standards, and the results, with certain theoretical conclusions, were presented in a brief paper read at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, Chicago, Sept. 24, 1919. The composition of the materials used ranged from C 3.67 to 3.90, Si 0.55 to 0.64, S 0.10 to 0.20, P 0.31 to 0.34 and Mn 0.53 to 0.63. Such variation in analysis did not affect the results, except that with higher carbons the temperature range at which graphitization is complete is somewhat more narrow. Speed of graphitization varies directly with the annealing temperature, but no considerable precipitation of carbon from these white irons occurred at 730 deg. C., even after 48 hours. This may therefore be taken as a safe annealing temperature for car wheels.

A curious fact was noted, that iron annealed at 1100 deg. C. and furnace cooled showed less graphite than another annealed for the same period at 1000 deg. C.



PORTION OF IRON-CARBON EQUILIBRIUM DIAGRAM

and cooled in the furnace, when practically all pre-eutectoid cementite had been decomposed. Quenching after annealing corroborated this observed difference. Upon slow cooling there is considerable crystallization of graphite upon the nuclei present, but a sample annealed at 1100 deg. C., cooled slowly to 1000 deg. C. and quickly cooled will have less graphite than one annealed at 1000 deg. C. and then quickly cooled. The authors present a diagram (shown herewith), to explain these facts. At 1100 deg. there is an amount of carbon in solid solution equal to C'C; at 1000 there is, if in equilibrium, a lesser amount equal to F'F. On cooling from 1100 deg. there is apparently a lag in its separation, not following line BS, but some line CS. Consequently upon arriving at the eutectoid horizontal, the combined carbon left in solid solution precipitates out as pearlite, and in amount will be greater in the sample cooled from 1100 than that from 1000. The graphite crystallizing about pre-existing nuclei along lines CS and FF'' is thus thought to come directly from solid solution. The fact that only 0.20 per cent of combined carbon

was found in some specimens after annealing and slow cooling would either indicate that the graphite eutectoid lies at much lower carbon content than previously supposed, that a graphite eutectoid is precipitated on slow cooling, or that pearlite breaks up into graphite and iron directly upon its formation.

## Recent Chemical and Metallurgical Patents

### American Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

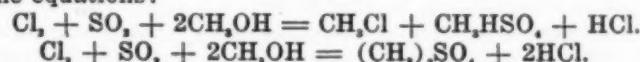
**Acetone From Acetic Acid.**—Vapors of acetic acid are passed over a catalyst consisting of a manganese salt, metallic manganese or alloys of manganese, such as ferromanganese of high Mn content. The use of a metallic or alloy catalyst containing manganese presents the advantages, among others, that no extraneous support, such as pumice or the like, is required in order to present a large surface of catalyst to the vapors; and the relatively high heat conductivity of such catalyst renders it possible to maintain the temperature conditions practically constant, as well as uniform, throughout the reaction zone. At a temperature of 490 to 500 deg. C. yields of 95 to 98 per cent theoretical are obtained. (1,315,525; HARRY A. MORTON, assignor, to Union Carbide Co.; Sept. 9, 1919.)

**Electrothermic Production of Acetylene From Hydrocarbons.**—By introducing a high-frequency alternating current arc discharge beneath the surface of a hydrocarbon liquid, GEORGE O. CURME, JR., obtains a gaseous mixture containing hydrogen and acetylene. Using solar oil approximately 8.5 cu.ft. of gas was obtained per hour with a power input of 6.1 kw. for eight arcs in series. A frequency of 300,000 cycles or over is desirable. The gas analyzed: Hydrogen, 50 per cent; acetylene, 25 per cent; ethylene, 12.5 per cent; methane, 7 per cent; other hydrocarbons, 5 per cent. Approximately 4.5 lb. of carbon in the form of carbon-black distributed through the oil, and about 3.3 lb. of carbon in the form of electrode deposits, was produced per 1000 cu.ft. of crude gas. The oil consumption was about 50 lb. per 1000 cu.ft. of gas. (1,315,540; assigned, by mesne assignments, to Union Carbide Co.; Sept. 9, 1919.)

**Acetaldehyde and Acetic Acid From Ethylene.**—Ethylene combines with mercuric sulphate in aqueous solution to form a compound of the type  $HgSO_4 \cdot C_2H_4$ , which yields acetaldehyde and acetic acid by electrolytic oxidation. The cell consists of a steam-jacketed tank, mercury cathode, porous diaphragm and an anode of platinum, lead peroxide, magnetite or other suitable material. The anolyte is dilute sulphuric acid containing mercuric sulphate, the catholyte dilute sulphuric acid. The presence of cerium salts in the anode chamber acts catalytically in favoring the oxidation. Ethylene is passed into the anolyte through a perforated ring. If it is desired to produce acetaldehyde, the solution is heated above 21 deg. C., so that the acetaldehyde is volatilized as formed. If, however, acetic acid is the product required, the gas outlet is closed and the acetaldehyde is thus held in solution and further oxidized to acetic acid. (1,315,543 and

1,315,546; GEORGE O. CURME, JR., assignor, by mesne assignments, to Union Carbide Co.; Sept. 9, 1919.)

**Production of Dimethyl Sulphate.**—Anhydrous alcohol is saturated with SO<sub>2</sub> and treated with a mixture of SO<sub>2</sub> and Cl, in the proportions indicated by the equations:



During the reaction, part of the methyl chloride is carried off by the excess SO<sub>2</sub>, and the HCl formed. By heating the product on a water bath, the CH<sub>3</sub>Cl, SO<sub>2</sub>, and HCl remaining in solution are vaporized. The methyl chloride can be isolated from the gaseous products by passing through an alkaline absorption medium which will combine with the SO<sub>2</sub> and HCl. The product still contains methyl hydrogen sulphate, but by distilling under diminished pressure, this is converted into dimethyl sulphate and sulphuric acid, which may be easily fractionated.



Yields of well over 50 per cent by weight of dimethyl sulphate are obtained, which, in conjunction with methyl chloride also produced, represents a yield approaching the theoretical. (1,317,648; THOMAS H. DURRANS, assignor to A. Boake, Roberts & Co., Ltd., Stratford, London; Sept. 30, 1919.)

**Apparatus for Treating Fuller's Earth.**—The impurities contained in fuller's earth which has been used for filtering or bleaching hydrocarbon oils are soluble in sulphuric acid, so that the earth can be re-used after an acid treatment. The process consists in placing the earth in a vat and allowing sulphuric acid to percolate through the mass. The excessive time required in the method has led CLIFFORD M. HUSTED of Jersey City to devise an apparatus in which the complete purification (including washing and drying) may be accomplished in approximately one-half hour. The earth to be treated and the purifying chemical, sulphuric acid, are fed continuously into a rotating drum equipped with baffles to insure thorough mixing, and flanges to retard the passage of the mixture through the drum so that the earth is retained long enough to insure adequate treatment. The earth is now discharged into a washer and separating tank, where it is washed by a continuous stream of water. The bottom of the tank is inclined and provided with a screw conveyor which carries the settled earth to a second washer. From this the earth passes to a rotary drier. (1,317,372; assigned to Standard Oil Co.; Sept. 30, 1919.)

**Graphitized Electrodes.** — The manufacture of graphitized electrodes up to and including the 12-in. sizes which are the present commercial size limit involves the following essential steps: Petroleum coke, a low-ash, low-sulphur residue from petroleum distillation, is crushed and then calcined or "shrunk" by heating to approximately 1000 to 1100 deg. C., usually in a gas- or oil-fired kiln. Thereby the hydrocarbons which are volatile at or below the calcining temperature are largely expelled. The calcined material is again crushed, graded, bonded with pitch or similar heavy hydrocarbon, and molded or extruded through dies into the appropriate electrode sections. The resulting so-called green electrodes are then baked in gas-fired kilns, usually at a maximum temperature of about 1000 deg. C. They are then ready for graphitization, which is carried out in electric

resistance furnaces at a much higher temperature range (above 2000 deg. C.). The principal advantages secured through graphitization are a large increase in electrical conductivity, and a marked decrease in the tendency to oxidation at the working temperature of the furnace. The present limit of industrial graphitization is reached at a diameter of approximately 12 in., either for round or square sections. As this limit is approached the proportion of losses through breakage or by the development of cracks or other defects undergoes a relatively very rapid increase, with the result that there exists a rather definite size limitation, above mentioned, beyond which graphitization has not up to the present time been commercially practiced. The breakage and the development of defects referred to occur partly during the baking of the electrodes prior to graphitization, and partly in the graphitizing operation itself.

In case graphitization is not desired, it is for many purposes advantageous to use in the electrode mix, instead of the low-ash petroleum coke, certain forms of carbon particles which are higher in ash but more compact, and of greater mechanical strength, notably hard coal of anthracite type. This coal is preliminarily calcined or shrunk to expel volatile matter, this operation being most advantageously carried out in electric calcining furnaces at relatively very high temperatures, up to 1600 to 1800 deg. C. This material is then crushed, graded, bonded and shaped, substantially as above described, and the green electrodes are then baked at about 1000 deg. C. to form the finished commercial article. Graphitization of these hard coal electrodes has not been commercially practiced. ARTHUR H. HINCKLEY of Niagara Falls has succeeded in making electrodes up to 24 in. in diameter from anthracite coal particles which can be graphitized. The process outlined above is modified as follows: The finely powdered anthracite coal (45 per cent to pass through a 200-mesh screen) is mixed with 12 to 15 per cent pitch in kneaders at 160 deg. C. The mass is briquetted in a steam-heated hydraulic press and baked at 1000 deg. C. The baked material is crushed and graded and is then ready for use. It is superior to the electrically calcined coal generally employed, since it has sufficient tensile strength to endure without fracture the strains set up in the electrode during the heating and cooling operations incident to baking and graphitizing, thus permitting the successful manufacture of larger electrodes. (1,317,497 and 1,317,498; assigned to National Carbon Co.; Sept. 30, 1919.)

**Detinning Process.**—Scrap tin is treated with a strong aqueous solution of caustic soda at 120 to 150 deg. F. in an iron tank which is lined with some material electro-negative to tin, such as graphite. The galvanic action set up between the graphite and the tin accelerates the solution of the tin. This operation is repeated until the bath is rich in tin. The tin solution is then transferred to a second iron tank. Bales of scrap tin are suspended in the bath and a current is passed, the tank being the cathode and the tin the anode. In this manner the tin from the bale is dissolved and deposited, while the tin is also deposited from the bath, so that the latter can be returned to the first tank. (1,316,926; CHARLES P. TATRO and GEORGE DELIUS of Seattle, assignors of one-third to BENJAMIN R. BRIERLY; Sept. 23, 1919.)

**Cymene Sulphonic Acids.**—Sulphuric acid of specific gravity 1.84 is caused to descend over baffle-plates, pebbles or coarse pumice stones, in a tower, which is heated and maintained at a temperature of 180 to 190 deg. C. Paracymene is heated to boiling and its vapors are passed up through the tower. The vapors come into contact with the descending hot sulphuric acid and are completely absorbed by it, with the formation of water and cymene disulphonic acids. The water escapes from the tower as steam and may be condensed in any suitable condenser attached at or near the top of the tower. The sulphonic acids, together with a slight excess of unused sulphuric acid, are carried downward by means of gravity, and discharged from the bottom of the tower. The product contains a considerable amount of cymene-2-sulphonic acid, which is separated from the disulphonic acid by well-known means, such as, for example, the formation of the barium salts by neutralizing with barium carbonate, filtering the solution of the salts of the sulphonic acids from the barium sulphate and concentrating the vapor to crystallization, when the barium salt of the monosulphonic acid of cymene separates first, leaving the barium salt of the disulphonic acid in solution, from which it may be obtained by the addition of alcohol. (1,316,823; JOSEPH A. AMBLER, HERBERT A. LUBS and HARRY D. GIBBS; filed under the act of March 3, 1883, 22 Stat. L., 625; Sept. 23, 1919.)

## Book Reviews

**INDUSTRIAL ELECTROMETALLURGY, INCLUDING ELECTROLYTIC AND ELECTROTHERMAL PROCESSES.** By Eric K. Rideal. 259 pages. 25 illustrations. New York: D. Van Nostrand Co.

The history of the English chemical industry within the past fifty years is unique in many respects. Much of the pioneer work of the chemical key industries, such as the dye industry, was carried out in England. The industries were fostered and developed and soon became foremost in the world. Thereupon a period of relaxation set in, the industries became of secondary importance or they left the Empire entirely. Such was the case of the dye industry, which virtually passed out of existence in England and grew to enormous proportions in Germany; of the aluminum industry, which went to America; and of the tungsten industry, which became a German monopoly. These facts were pointed out by the British Association about fifteen years ago, when an earnest endeavor was made to revive the chemical and metallurgical industries at home; but it remained for the World War to make the English people fully realize the actual status of their industries. Soon after the outbreak of the war the chemist was called upon to produce chemicals and chemical products which had previously been imported from Germany and Austria. An urgent demand immediately arose for concise accounts of the best and most modern methods of making the chemical products in question. In response to this demand a number of the foremost British chemists and engineers arranged to publish series of practical handbooks. The book before us is the third in a series edited by Samuel Rideal. The remarkable rebirth and rapid development of the British chemical industries within the past three years is without doubt largely due to the untiring efforts of these chemists and engineers.

Dr. Rideal's book will be welcomed by American chemists and instructors, but in particular by the young electro-chemist. The subject is admirably well treated and attractively printed and illustrated. The book is divided into the following eight chapters: Electrolysis in aqueous solu-

tions; electrolysis in fused electrolytes; electrolytic preparation of the rarer metals; electrothermal processes; carborundum and oxysilicides of carbon; carbides; electro-thermal nitrogen fixation by metals and metallic compounds; iron and the ferro-alloys. Not only are the various processes described from the technical point of view but considerable space is devoted to the underlying theories of the several chemical or thermal reactions. Those who wish to make a more thorough study of the subject will find the numerous literature references very convenient. There are very few misprints and but few misstatements. On page 92 the author states that there "has been no electrolytic process devised for the refining of tin," although America has been turning out electrolytic tin since 1916. The process was described in the *Engineering and Mining Journal* of that year. These minor defects will undoubtedly be removed in the second edition, which will surely appear, judging by the great popularity of this first edition.

COLIN G. FINK.

## Personal

H. G. BAIN, until recently attached to the San Francisco office of the Midvale Steel & Ordnance Co. sales organization, has joined the Tacony Steel Co., Philadelphia, Pa., as sales representative for the upper part of New York State.

R. E. BAKER has resigned as works manager of the Keokuk Electro Metals Co. to accept a position as research engineer for the Victor Chemical Works at Chicago Heights, Ill.

ROY BRAKEMAN, formerly chief engineer of the Fairfield Works of the American Steel & Wire Co., Fairfield, Ala., is now associated with the Otis Steel Co., Cleveland, Ohio, as chief engineer.

S. E. BRETHERTON, JR., who recently returned from the Burma Mines Co., is now at Atascadero, Cal.

E. F. BRUNDAGE has severed his connection with the Maryland Chemical Co. and is now with the General Chemical Co., Baltimore, Md.

DR. CHARLES F. CHANDLER of Columbia University is to be the recipient of the Perkin medal to be awarded at the meeting of the Society of Chemical Industry this month.

GEORGE C. DEWEY, recently in the U. S. Army, is now chemist and assayer with the Selby Smelting & Lead Co., at Selby, Cal.

DR. F. GIOLITTI is in the United States on a mission from Stein & Co. of Paris, France, who have organized an American branch to exploit their ideas in gas furnace construction.

M. R. HULL has resigned his position as designing engineer and superintendent of power for the Nevada Consolidated Co. to accept a position as designing engineer for the affiliated companies the Chile Exploration Co. and the Braden Copper Co., with headquarters in New York City.

HENRY S. KENYON, formerly with the Thomas A. Edison Co., is head of the oil and wax division of the Southern Oil & Chemical Co., 21 Park Row, New York.

EDWARD D. KILBURN, who has been New York district manager of the Westinghouse Electric & Manufacturing Co., was recently elected vice-president and general manager of the Westinghouse Electric International Co.

F. G. MOSES, formerly at the Salt Lake City station of the Bureau of Mines, is now connected with The Barrett Co., in charge of the flotation oil department.

WILLIAM C. REDFIELD, Secretary of Commerce for seven years, has associated with H. P. Wilson in the investment security business under the name of Redfield & Wilson, 50 Broad St., New York City.

HUGH ROLLIN, formerly president of the Rollin Chemical Corp., is no longer president and general manager of the company, owing to a change in the stock control, and has severed all connection with the company.

DOUGLAS E. SCOTT, who for several years has been in charge of the experimental paper mill of Arthur D. Little,

Inc., Cambridge, Mass., has resigned and is now connected with the United Fruit Co., Boston, Mass.

HERVEY J. SKINNER, for many years vice-president of Arthur D. Little, Inc., Cambridge, Mass., has severed his connection with that organization and has opened an office as a consulting chemical engineer at 248 Boylston St., Boston, Mass. Mr. Skinner was with the Arthur D. Little, Inc., organization seventeen years, during which time it grew to its present large size, occupying a large modern laboratory building on the Charles River in Cambridge. Mr. Skinner has had a varied experience especially in pulp and paper problems and will specialize in development work on propositions requiring technical advice and assistance in putting them into commercial operation.

## Current Market Reports

### The Non-Ferrous Metal Market

New York, Jan. 5.—Copper holds steady at 19c. for near-by delivery, 19½c. for future delivery. There has been very little trading in tin, the February-March quotation being 58½c. Lead and zinc are both firm.

	Cents per Lb.
Copper, electrolytic.....	19.00
Aluminum, 98 to 99 per cent.....	33.00
Antimony, wholesale lots.....	9.75
Nickel, ordinary.....	42.00
Nickel, electrolytic.....	45.00
Tin, Straits, spot.....	58.25
Lead, New York, spot.....	7.75
Lead, E. St. Louis, spot.....	7.50
Zinc, spot, New York.....	9.25
Zinc, spot, E. St. Louis.....	8.87½
Silver.....	1.35
(Dollars per oz.)	

### FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled.....	28.50
Copper sheets, cold rolled (over 14 oz.).....	30.50
Copper bottoms.....	37.00
Copper rods.....	29.50
High brass wire and sheets.....	25.50
High brass rods.....	24.50
Low brass wire and sheets.....	28.25
Low brass rods.....	28.25
Brazed brass tubing.....	37.25
Brazed bronze tubing.....	42.00
Seamless copper tubing.....	32.00
Seamless bronze tubing.....	36.00
Seamless brass tubing.....	30.50

### SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap.....	23½ @ 24½
Aluminum, sheet scrap.....	22½ @ 23½
Aluminum clippings.....	25½ @ 27
Copper, heavy machinery comp.....	14½ @ 14½
Copper, heavy and wire.....	13½ @ 14
Copper, light and bottoms.....	12½ @ 12½
Copper, heavy cut and crucible.....	15½ @ 16
Brass, heavy.....	7½ @ 8½
Brass, casting.....	10½ @ 10½
Brass, light.....	5½ @ 6½
No. 1 clean brass turnings.....	8½ @ 8½
No. 1 comp. turnings.....	11½ @ 12
Tea lead.....	4.65 @ 4.75
Lead, heavy.....	6.00 @ 6.25
Zinc, scrap.....	4½ @ 4½

### RARER METALS

	lb. \$1.50 @ 2.50
Cadmium.....	lb. 1.90
Cobalt.....	1.90
Platinum.....	150.00
Iridium.....	250.00
Palladium.....	150.00

## The Iron and Steel Market

Pittsburgh, January 2, 1920.

Marketing problems in the iron and steel trade are relegated altogether to the rear, but there is much shopping on the part of jobbers and manufacturing consumers, who do not merely wish to match a certain piece of goods but rather are in search of material of all sorts for prompt delivery. They are quite bare of stocks, and shopping is likely to be more strenuous in the next few weeks than it was even in December. In contracting, on the other hand, there is little being done and little is to be expected in the next two months. Substantially all the tonnage the mills were willing to place under contract for the first quarter or half of the new year has been disposed of.

With the mills it is a question of production and distribution. The Steel Corporation and several of the inde-

pendent producers have adhered to the March 21 or Industrial Board schedule of prices, and as higher prices would be paid by many buyers, and have been paid to some of the independent mills on comparatively large tonnages, it is necessary for producers who have sold at the basis prices to distribute their output very carefully so that regular customers may receive their appropriate quotas.

### STEEL PRODUCTION PROSPECT BRIGHT

As to production, there is a reasonable prospect that within three or four months the mills will be able to approach measurably close to capacity output. In January, 1919, steel ingot production was about 87 per cent of capacity, output decreasing until approximately a 50-per-cent rate was reached at the middle of May, an increase at once beginning which brought the industry up to about an 83-per-cent rate in the fore part of September. The strike inaugurated Sept. 22 cut output by about one-half, and since then there has been a gradual recovery, production at the present time being at about 80 per cent. The strike is left behind, but labor shortage, labor inefficiency and lowered morale remain, the objective now being to correct the situation in these respects.

The present deficit in steel supply can of course be made up readily, provided production can be increased to the extent that should be expected and that consumptive demands do not very greatly increase. With capacity operation there would soon be room for the railroads to re-enter the market as buyers, and this is expected to occur. In all probability the large mills that have hitherto catered to railroad demand have been endeavoring to save some space for the railroad owners when control of their properties is returned to them March 1.

The acute deficit in steel supplies probably amounts to several hundred thousand tons, while the deficit represented by stocks in the hands of jobbers and manufacturing consumers being below normal may amount to more than a million tons. Capacity, however, in finished rolled steel is about 725,000 gross tons a week, while production is now at 550,000 to 600,000 tons a week, so that the case is far from hopeless. The longest time estimated for the trade to "catch up" and regain a normal basis is six months.

### PRICE POLICIES AND PREMIUMS

Last March an agreement was reached between the "Industrial Board" set up by Secretary Redfield of the Department of Commerce and representatives of the iron and steel industry whereby certain price reductions would be made in the interest of stabilization of prices so that investors would be encouraged to proceed. Both parties to the agreement made statements that buyers should expect to buy, during 1919, at lower prices than those announced to become effective March 21. Within a short time the Industrial Board disappeared. In May and June various independent producers were cutting the March 21 prices, but the Steel Corporation and a few independents did not. Later, when the market was in position to advance, the Steel Corporation showed steadfast adherence to the regular schedule.

All that was positively known was that the Steel Corporation intended to adhere to the schedule during 1919, but a definite pronouncement has now been made showing that the Steel Corporation intends to continue the policy for an indefinite time, or until conditions radically change. Judge Gary, chairman of the Steel Corporation, in a statement given out after the directors' meeting of Dec. 30, indicated the corporation's adherence at this time to the policy, so that no change is to be expected even though 1919 has passed into history. With the Steel Corporation are several of the large independent producers and perhaps a few of the smaller producers. Higher prices than the March 21 schedule have been paid freely for early deliveries of the majority of finished steel products, but in the circumstances such prices must be regarded as "premium prices," the excess being due to the delivery time involved. Those who pay the premium prices are buyers who have no regular standing as customers of the mills adhering to the basis prices, or customers who desire tonnage in addition to that allotted them.

## The Chemical and Allied Industrial Markets

New York, January 2, 1920.

The general chemical market remains firm, with better prices and smaller sales. The quotation on *oxalic crystals* jumped from 30@31c. per lb. to 31@32c. per lb. on car lots, and from 30@33c. per lb. to 32@35c. on less than car lots. *Calcium chloride*, fused lump, has been active, and as a consequence the low price has come up from \$19 to \$20 per ton, showing a present quotation of \$20@\$25 per ton on car lots and \$30@\$40 on smaller quantities. *Carbon tetrachloride* also jumped 1c., the present quotation reading 12½@14½c. per lb. *Potassium bichromate*, among the leaders in activity, is quoted at 32@33c. per lb. in car lots and 34@35c. per lb. in less than car lots, against 26@27c. and 30@33c. of the previous report. *Potassium permanganate* rose from 55@65c. to 70@75c. per lb., while *potassium prussiate red* went up to \$1.10@\$1.20 per lb. against \$1.05@\$1.15 of last week.

*Alcohol* at present is on a very unstable footing owing to the uncertainty as to the future of this item. *Ethyl* and *denatured alcohol* continue at the same nominal quotations of \$5.25@\$7 per gal. on the former and 80@82c. per gal. on the 188 proof and 76@78c. on 190 proof, denatured. *Methyl*, or *wood alcohol* is unobtainable, and the price has jumped to \$1.57 per gal., against a high mark of \$1.38 for last week. In order to restrict the sale of wood alcohol the Internal Revenue Department is bonding all handlers of this item.

*Coal-tar products* have exhibited nothing of especial interest, prices remaining firm. *Dimethylaniline* is still going up and is now quoted at 90c.@\$1, against 60@93c. per lb. of the previous report, and there is very little on the market to be had even at this increased price. *Phenol* jumped from a previous high mark of 16c. to 19c. per lb., while *phthalic anhydride* is quoted at 70c.@\$1 per lb.

*Waxes* have been inactive during the past week and prices remain unchanged. The *paraffine grades* are still behind in production, which partially accounts for the high prices at present. All contracts being written at present are for future delivery.

In *naval stores* the lower and medium grades are displaying an upward tendency in price, *rosin EI* rising to \$19 for 280 lb., against \$18.25 of last week. *Wood turpentine*, dest. dist., is now quoted at \$1.51@\$1.58 per gal.

In order to meet the demand of the buyers the prices of some of the vegetable oils have been dropped slightly, *olive oil* commercial coming down from \$2.80 to \$2.60 per gal., while *palm lagos* dropped a cent to 16c. per lb. *Rapeseed oil blown* came up 10c., with a range at present of \$1.60@\$1.70 per gal., while *rapeseed oil refined* also went up 5c. to \$1.65 per gal.

Another gap has been caused by the holiday and the absence of cables from the English and India rubber market leaves the domestic market somewhat unstable. Prices have gone up, with *up-river coarse* quoted at 36@37c. per lb., against 35c. last week, while *caucho ball* jumped from 51½c. to 54½c.

The *ferro-alloy* market remains practically unchanged, the only activity being in *spiegeleisen*, which jumped from \$33@\$45 to \$40@\$50 per gross ton. The low quotation on *ferromanganese* dropped to \$100, making the present quotation \$100@\$130 per gross ton.

An active market in the ores and semi-finished products is predicted for the near future, the present prices, however, remaining.

Among the miscellaneous materials, *fuller's earth* is still scarce. Owing to uncertain labor conditions in Florida, the domestic grade of this item is practically unobtainable at \$25@\$30 per ton. *Barytes*, domestic white floated, which has been in heavy demand by the paint industry, is hard to find. The former quotation of \$35@\$40 per ton remains.

Chicago, December 31, 1919.

Firm prices in most lines mark the closing days of 1919 in the local market, excellent demand holding in all branches of the trade. A sharp decline has been experienced in pine tar products, but renewed demand is now tending to reestablish former high prices.

**Heavy Chemicals:** The formerly noted upward trend of *caustic soda* has been accentuated by heavy export shipments of granulated to Europe, \$4.50 cwt. now being the ruling price, f.o.b. works. Domestic purchases of solid are also heavy and \$4 f.o.b. works is quoted. *Bleach* also has taken a further advance to 2½c. and *soda ash*, light, ranges from \$2 to \$2.10 per cwt. Indications are that the market on the above-mentioned items is practically fixed for some time at the prices named.

**Sodium bichromate** has recovered from its violent spurt of three weeks ago when prices were named ranging from 30 to 40c. per lb. The price now is established, for the time, at least, at about 22c. Other items which have had interesting fluctuations recently are all holding firm, *potassium carbonate* being quoted at 27c., *acetone* at 15c. and *potassium prussiate, red*, \$1.10, *yellow*, 70c.

**Acids** show no changes of interest except in *sulphuric*, the market having strengthened some, current quotation on 66 deg. being \$22. *Muriatic*, 20 deg., at 2½c. and 40 deg. *nitric* at 8c. for spots show no change. Manufacturers report future production pretty well covered by contracts at prices only slightly less than those ruling for immediate delivery.

**Coal-Tar Products:** The effect of the coal strike was felt more keenly in this than in any other chemical line, as it curtailed production at a time when supply was already short on account of previous troubles in the steel industry. *Benzol* and *toluol* are hard to get in any great quantity, 32c. being the ruling price for available stocks. *Aniline oil* at 33c. and *aniline salts* at 36c. show no recent change. Supply on these two items is very short, and the prices quoted are for future delivery, spots demanding and receiving one or two cents more.

No great activity is noted in *benzoic acid*, 95c. being quoted on U. S. P. for today's delivery. *Salicylic acid* is under slightly better demand, 45c. still being asked. *Picric acid* is the weakest item of the line, plenty being offered at 20c. with no buyers visible at that figure.

**Vegetable Oils:** This line, owing to curtailment of users' activities during the coal strike, has been very quiet, but in the last few days a slight strengthening has been noted and indications are that some of the large consumers are preparing to enter the market for quantity contracts for future delivery. *Cotton oil*, crude, is today quoted 1c. higher at 19½c., and *prime summer yellow* advanced the same amount to 25½c. *Corn oil*, under the weak demand of the past few weeks, has done well to hold firm at 18c., sellers' tanks. *Linseed oil* some time ago advanced to \$1.85 in tanks, \$2.09 being asked for local deliveries in lots of 4 bbl. or less. With speculation rife as to the distribution of the forthcoming Argentine crop of seed, and with all crushers sold up to capacity for some time to come, it looks as if high prices in *linseed oil* will remain for some weeks at least.

With light demand, market in *cocoanut oil* and *soya bean oil* has been quiet, a slight firmness being felt in the last few days. At existing rates of exchange with the Orient, lower prices seem impossible. On *cocoanut oil* 18½c. in tanks, f.o.b. coast, is asked and 16½c. on *soya bean oil*.

**Flotation Oils, Naval Stores:** A sharp decline due to a weakening of demand, which in turn was due to the fuel shortage, occurred about ten days ago. From the previous high mark of \$1.60@\$1.65, .933 *pure distilled pine tar oil* has dropped to \$1.35, and *destructively distilled* is quoted at the same figure. *Turpentine*, being shortest in supply, has fluctuated less, \$1.85 now ruling against \$1.95@\$1.98 in the middle of December. *Rosin* shared slightly in the decline, quotation on F grade having dropped 50c. to \$18.50.

**Fertilizers:** While the temporary shutdown of the great fertilizer plants here during the bituminous strike was not of sufficient length to seriously affect production for the year, it had the effect of skyrocketing prices on the local market. *Ground blood* is hard to get at the prevailing price of \$7.75 and *unground* is quoted at about \$7.50, a recent advance on the two lines of 40c. and 75c. respectively. *Tankage* is also up nearly 50c., quotation of high-grade *ground* being \$7.25. All other grades are priced in proportion.

## General Chemicals

## CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....	lb. \$0.20	.21
Acetone.....	cwt. 2.50	\$2.75
Acid, acetic, 28 per cent.....	cwt. 3.00	5.50
Acetic, 56 per cent.....	cwt. 3.00	5.50
Acetic, glacial, 99% per cent, carboys.....	cwt. 13.00	13.50
Boric, crystals.....	lb. .15	.15
Boric, powder.....	lb. .14	.15
Hydrochloric (muriatic), tech. 20 deg. ....	cwt.	2.25 - 2.50
Hydrofluoric, 52 deg.....	lb. .12	.14
Lactic, 44 per cent tech.....	lb. .05	.06
Lactic, 22 per cent tech.....	lb. .05	.06
Molybdic, C. P.....	lb.	4.00 - 4.25
Nitric, 40 deg.....	lb. .06	.06
Nitric, 42 deg.....	lb. .07	.07
Oxalic, crystals.....	lb. .31	.32
Phosphoric, Ortho, 50 per cent solution.....	lb. .09	.10
Picric.....	lb. .30	.35
Pyrogalllic, resublimed.....	lb.	2.30 - 2.60
Sulphuric, 60 deg., tank cars.....	ton 12.00	- 16.00
Sulphuric, 60 deg., drums.....	ton 17.00	-
Sulphuric, 60 deg., carboys.....	ton 20.00	-
Sulphuric, 66 deg., tank cars.....	ton 17.00	- 18.00
Sulphuric, 66 deg., drums.....	ton 20.00	- 21.00
Sulphuric, 66 deg., carboys.....	ton 23.00	-
Sulphuric, fuming, 20 per cent (oleum) tank cars.....	ton 20.00	-
Sulphuric, fuming, 20 per cent (oleum) drums.....	ton 25.00	-
Sulphuric, fuming, 20 per cent (oleum) carboys.....	ton 30.00	-
Tannic, U. S. P.....	lb. .35	.45
Tannic (tech.).....	lb. .42	.55
Tartaric, crystals.....	lb. .69	.74
Tungstic, per lb. of WO <sub>3</sub> .....	lb. 1.20	.40
Alcohol, Ethyl.....	gal. 4.80	- 4.95
Alcohol, Methyl.....	gal. 1.50	-
Alcohol, denatured, 188 proof.....	gal.	1.52 - 1.57
Alcohol, denatured, 190 proof.....	gal.	.80 - .82
Alum, ammonia lump.....	lb. .04	.04
Alum, potash lump.....	lb. .08	.08
Alum, chrome lump.....	lb. .15	.16
Aluminum sulphate, commercial.....	lb. .01	.02
Aluminum sulphate, iron free.....	lb. .02	.03
Aqua ammonia, 26 deg., drums (750 lb.).....	lb. .08	.09
Ammonia, anhydrous, cylinders (100-150 lb.).....	lb. .13	.13
Ammonium carbonate, powder.....	lb. .13	.14
Ammonium chloride, granular (white sal ammoniac).....	lb. .12	.14
Ammonium chloride, granular (gray sal ammoniac).....	lb. .12	.12
Ammonium nitrate.....	lb. .10	.11
Ammonium sulphate.....	lb. .05	.06
Amylacetate.....	gal.	3.65 - 3.75
Arsenic, oxide, lumps (white arsenic).....	lb. .09	.09
Arsenic, sulphide, powdered (red arsenic).....	lb.	90.00 - 95.00
Barium chloride.....	ton 95.00	- 100.00
Barium dioxide (peroxide).....	lb. .22	.24
Barium nitrate.....	lb. .09	.10
Barium sulphate (precip.) (blanc fixe).....	lb. .03	.03
Bleaching powder (see calcium hypochlorite).....	-	-
Blue vitriol (see copper sulphate).....	-	-
Borax (see sodium borate).....	-	-
Brimstone (see sulphur, roll).....	-	-
Bromine.....	-	.65 - .75
Calcium acetate.....	cwt. 2.00	- 2.05
Calcium carbide.....	lb. .04	.05
Calcium chloride, fused, lump.....	ton 20.00	- 25.00
Calcium chloride, granulated.....	lb. .01	.01
Calcium hypochlorite (bleaching powder)....	cwt.	2.75 - 3.75
Calcium peroxide.....	lb. .15	.20
Calcium phosphate, monobasic.....	lb. .02	.03
Calcium sulphate, precipitated.....	lb. .09	.09
Carbon bisulphide.....	lb. .05	.06
Carbon tetrachloride, drums.....	lb. .10	.11
Carbonyl chloride (phosgene).....	lb. .12	.14
Caustic potash (see potassium hydroxide).....	-	-
Caustic soda (see sodium hydroxide).....	-	-
Chlorine, gas, liquid-cylinders (100 lb.).....	lb. .05	.05
Cobalt oxide.....	lb.	1.50 - 1.55
Copper (see iron sulphate).....	-	-
Copper carbonate, green precipitate.....	lb. .28	.31
Copper cyanide.....	lb. .65	.70
Copper sulphate, crystals.....	lb. .08	.08
Cream of tartar (see potassium bitartrate).....	-	-
Epsom salt (see magnesium sulphate).....	-	-
Formaldehyde, 40 per cent.....	lb. .20	.37
Glauber's salt (see sodium sulphate).....	-	-
Glycerine.....	lb. .24	.26
Iodine, resublimed.....	lb. 4.50	-
Iron oxide, red.....	lb. .03	.20
Iron sulphate (coppers).....	cwt. 1.00	-
Lead acetate, normal.....	lb. .15	.16
Lead arsenate (paste).....	lb. .13	.17
Lead nitrate, crystals.....	lb. .85	.86
Litharge.....	lb. .09	.10
Lithium carbonate.....	lb. .50	.55
Magnesium carbonate, technical.....	lb. .13	.14
Magnesium sulphate, U. S. P.....	100 lb. 2.00	- 2.63
Magnesium sulphate, commercial.....	100 lb. 1.75	-
Nickel salt, double.....	lb. .14	.15
Nickel salt, single.....	lb. .12	.15
Phosgene (see carbonyl chloride).....	-	-
Phosphorus, red.....	lb. .75	.90
Phosphorus, yellow.....	lb. .35	.37
Potassium bichromate.....	lb. .32	.33
Potassium bitartrate (cream of Tartar).....	lb. .58	.60
Potassium bromide, granular.....	lb. .50	.65
Potassium carbonate, U. S. P.....	lb. .60	.65
Potassium carbonate, crude.....	lb. .25	.30
Potassium chlorate, crystals.....	lb. .18	.20
Potassium cyanide, 98-99 per cent.....	lb. nominal	.21
Potassium hydroxide (caustic potash).....	lb. .28	.32
Potassium iodide.....	lb. .35	.36
Potassium nitrate.....	lb. .19	.21
Potassium permanganate.....	lb. .70	.75
Potassium prussiate, red.....	lb. 1.10	- 1.20

\*Nominal quotations.

	Carlots	Less Carlots
Potassium prussiate, yellow.....	lb.	\$0.40 - \$0.70
Potassium sulphate.....	ton 5223.00	-
Rochelle salts (see sodium potas, tartrate).....	-	-
Sal ammoniac (see ammonium chloride).....	-	-
Salt cake (sodium sulphate).....	ton 15.00	- 21.00
Silver cyanide.....	oz.	1.25
Silver nitrate.....	oz.	.81
Soda ash, light.....	100 lb. 1.95	- 2.05
Soda ash, dense.....	100 lb. 2.25	- 2.35
Sodium acetate.....	lb. .05	.06
Sodium bicarbonate.....	100 lb. 2.35	-
Sodium bisulphite (nitre cake).....	ton 3.00	- 8.00
Sodium bisulphite.....	ewt. 1.80	- 1.90
Sodium borate (borax).....	lb. .09	.10
Sodium carbonate (soda).....	100 lb. 1.35	- 1.50
Sodium chlorate.....	lb. .15	.16
Sodium cyanide, 96-98 per cent.....	lb. .30	.31
Sodium fluoride.....	lb. .14	.15
Sodium hydroxide (caustic soda).....	100 lb. 4.10	- 4.35
Sodium molybdate.....	lb. 2.50	-
Sodium nitrate.....	100 lb. 3.25	- 3.75
Sodium nitrite.....	lb. .15	.17
Sodium peroxide, powdered.....	lb. .03	.04
Sodium phosphate, dibasic.....	lb. .03	.04
Sodium potassium tartrate (Rochelle salt).....	lb. .43	.45
Sodium prussiate, yellow.....	lb. .23	.24
Sodium silicate, solution (40 deg.).....	lb. .01	.02
Sodium silicate, solution (60 deg.).....	lb. .02	.03
Sodium sulphate, crystals (Glauber's salt).....	1.15	- 1.25
Sodium sulphide, crystal, 60-62 per cent (cone).....	lb. .05	.06
Sodium sulphite, crystals.....	lb. .03	.04
Strontium nitrate, crystals.....	lb. .25	.28
Sulphur chloride.....	lb. .05	.06
Sulphur, crude.....	ton 22.00	-
Sulphur dioxide, liquid, cylinders.....	lb. .10	.12
Sulphur (sublimed), flour.....	100 lb. 3.10	- 3.65
Sulphur, roll (brimstone).....	100 lb. 2.95	- 3.15
Tin bichloride (stannous).....	lb. .44	.46
Tin oxide.....	lb. .60	-
Zinc carbonate, precipitate.....	lb. .20	-
Zinc chloride, gran.....	lb. .12	.14
Zinc cyanide.....	lb. .49	.50
Zinc dust.....	lb. .09	.11
Zinc oxide, dry American.....	lb. .09	.12
Zinc sulphate.....	lb. .03	.04

## Coal-Tar Products

Alpha naphthal, crude.....	lb. \$1.00
Alpha naphthal, refined.....	lb. 1.40
Alpha naphthylamine.....	lb. .32
Aniline oil, drums extra.....	lb. .34
Aniline salts.....	lb. .43
Anthracene, 80% in drums (100 lb.).....	lb. .90
Benzaldehyde (f.f.c.).....	lb. 1.00
Benzidine, base.....	lb. 1.10
Benzidine, sulphate.....	lb. .90
Benzoic acid, U.S.P.....	lb. .90
Benzol, pure, water-white, in drums (100 lb.).....	gal. .27
Benzol, 90%, in drums (100 lb.).....	gal. .25
Benzyl chloride, 95-97%, refined.....	lb. .35
Benzyl chloride, tech.....	lb. .25
Beta naphthal benzene.....	lb. .50
Beta naphthal, sublimed.....	lb. .75
Beta naphthal, tech.....	lb. .45
Beta naphthylamine, sublimed.....	lb. 2.25
Cresol, U.S.P., in drums (100 lb.).....	lb. .18
Ortho-cresol, in drums (100 lb.).....	lb. .23
Cresylic acid, 97-99%, straw color, in drums.....	gal. .80
Cresylic acid, 95-97%, dark, in drums.....	gal. .85
Cresylic acid, 50%, first quality, drums.....	gal. .60
Dichlorbenzol.....	lb. .07
Diethylaniline.....	lb. 1.40
Dimethylaniline.....	lb. .90
Dinitrobenzol.....	lb. .26
Dinitrobenzal.....	lb. .25
Dinitrophenol.....	lb. .32
Dinitrotoluol.....	lb. .38
Dip oil, 25%, tar acids, car lots, in drums.....	gal. .38
Diphenylamine.....	lb. .58
H-acid.....	lb. 1.60
Metaphenylenediamine.....	lb. 1.15
Monochlorbenzol.....	lb. .12
Naphthaline crushed, in bbls. (250 lb.).....	lb. 1.50
Naphthaline, flake.....	lb. .06
Naphthaline, balls.....	lb. .08
Naphthalionic acid, crude.....	lb. .75
Nitrobenzol.....	lb. .14
Nitro-naphthaline.....	lb. .40
Nitro-toluol.....	lb. .27
Ortho-amidophenol.....	lb. 3.00
Ortho-dichlor-benzol.....	lb. .15
Ortho-nitro-phenol.....	lb. .90
Ortho-nitro-toluol.....	lb. .25
Ortho-toluidine.....	lb. .25
Para-amidophenol, base.....	lb. 2.50
Para-amidophenol, HCl.....	lb. 2.50
Para-dichlor-benzol.....	lb. .15
Paranitraniline.....	lb. .95
Para-nitro-toluol.....	lb. 1.35
Paraphenylenediamine.....	lb. 2.50
Paratoluidine.....	lb. .70
Phthalic anhydride.....	lb. .12
Phenol, U.S.P., drums (dest.), (240 lb.).....	gal. 2.00
Pyridin.....	lb. 3.75
Resorcin, technical.....	lb. 6.50
Resorcin, pure.....	lb. .45
Salicylic acid, tech., in bbls. (110 lb.).....	lb. .45
Salicylic acid, U.S.P.....	lb. .45
Salol.....	lb. .90
Solvent naphtha, water-white, in drums, 100 gal.....	gal. .22
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal. .19
Sulphanilic acid, crude.....	lb. .25

Toluidine	lb.	\$1.70	—	\$2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	
Toluol, in drums	gal.	.32	—	.30
Xyldine, drums, 100 gal.	lb.	.44	—	.50
Xylo, pure, in drums	gal.	.37	—	.45
Xylo, pure, in tank cars	gal.	.35	—	
Xylo, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylo, commercial, in tank cars	gal.	.23	—	.27

**Waxes**

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	\$0.42	—	\$0.44
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.66
Carnauba, No. 1	lb.	.80	—	.83
Carnauba, No. 2, regular	lb.	.65	—	.78
Carnauba, No. 3, North Country	lb.	.44	—	.50
Japan	lb.	.18	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06	—	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	—	—	.06
Paraffine waxes, refined, 118-120 m.p.	lb.	—	—	.09
Paraffine waxes, refined, 128-130 m.p.	lb.	.09	—	.10
Paraffine waxes, refined, 133-135 m.p.	lb.	—	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	—	—	.13
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

**Flotation Oils**

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.	gal.	\$1.25
Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	1.00
Pine oil, pure, dest. dist.	gal.	.47
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.47
Pinetar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.65
Pine tar, ref., thin, sp. gr. 1.080-1.190	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.00
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.51
Pinewood creosote, ref.	gal.	

**Naval Stores**

The following prices are f.o.b., New York, for carload lots.	gal.	
Rosin B-D, bbl.	280 lb.	\$17.00
Rosin E-I	280 lb.	17.55
Rosin K-N	280 lb.	19.75
Rosin W. G.-W. W.	280 lb.	22.50
Wood rosin, bbl.	280 lb.	17.00
Spirits of turpentine	gal.	1.65
Wood turpentine, steam dist.	gal.	1.63
Wood turpentine, dest. dist.	gal.	1.51
Pine tar pitch, bbl.	200 lb.	8.25
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50
Retort tar, bbl.	280 lb.	15.00
Rosin oil, first run	gal.	.86
Rosin oil, second run	gal.	.88
Rosin oil, third run	gal.	.95
Rosin oil, fourth run	gal.	1.05

**Solvents**

73-76 deg., steel bbls. (85 lb.)	gal.	\$0.33
70-72 deg., steel bbls. (85 lb.)	gal.	.31
68-70 deg., steel bbls. (85 lb.)	gal.	.30
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

**Crude Rubber**

Para—Upriver fine	lb.	\$0.50	—	\$0.51
Upriver coarse	lb.	.36	—	.37
Upriver caucho ball	lb.	.36	—	.37
Plantation—First latex crepe	lb.	.54	—	
Ribbed smoked sheets	lb.	.54	—	
Brown crepe, thin, clean	lb.	.46	—	.48
Amber crepe No. 1	lb.	.53	—	

**Oils**

## VEGETABLE

Castor oil, No. 3, in bbls.	lb.	\$0.18	—	\$0.20
Castor oil, AA, in bbls.	lb.	.21	—	.22
China wood oil, in bbls.	lb.	.22	—	.24
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17	—	.19
Cocoanut oil, Cochin grade, in bbls.	lb.	.19	—	.22
Corn oil, crude, in bbls.	lb.	.19	—	.21½
Cottonseed oil, crude (f.o.b. mill)	lb.	.18	—	.19
Cottonseed oil, summer yellow	lb.	.22	—	.27
Cottonseed oil, winter yellow	lb.	.23	—	.28
Linseed oil, raw, car lots	gal.	1.80	—	1.87
Linseed oil, raw, tank cars	gal.	1.80	—	1.84
Linseed oil, boiled, car lots	gal.	1.90	—	
Olive oil, commercial	gal.	2.50	—	2.60
Palm, Lagoa	lb.	.16	—	.17½
Palm, bright red	lb.	.16	—	.17½
Palm, Niger	lb.	.16	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½	—	.23½
Peanut oil, refined, in bbls.	lb.	.26	—	.28
Rapeseed oil, refined in bbls.	lb.	1.45	—	1.65
Rapeseed oil, blown, in bbls.	lb.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.17	—	.22
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15½	—	.15½

**FISH**

Winter pressed Menhaden	gal.	\$1.20	—	
Yellow bleached Menhaden	gal.	1.23	—	
White bleached Menhaden	gal.	1.25	—	
Blown Menhaden	gal.	1.26	—	

**Miscellaneous Materials**

## All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	\$35.00	—	\$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06

Chalk, English, dense	lb.	\$ .04	—	\$ .05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	35.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	
Shellac, TN	lb.	1.10	—	1.15
Shellac, D. C.	lb.	—	—	
Shellac, V. S. O.	lb.	—	—	
Shellac, Diamond I.	lb.	—	—	
Shellac, orange, fine	lb.	1.25	—	
Shellac, orange, superfine	lb.	1.20	—	1.30
Shellac, A. C. garnet	lb.	1.10	—	
Shellac, bleached, bone dry	lb.	1.35	—	
Shellac, bleached, fresh ground	lb.	1.10	—	1.15
Sapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

**Refractories**

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

**Ferro-alloys**

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	\$200.00 — \$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8%	lb.	.20 — .40
Ferro-chrome, per lb. of Cr. contained, 2-4%	lb.	.21 — .50
Ferro-manganese, 70-80% Mn	gross ton	100.00 — 130.00
Spiegelisen, 16-20% Mn	gross ton	40.00 — 50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 — 3.50
Ferro-silicon, 50%	gross ton	85.00 — 95.00
Ferro-silicon, 75%	gross ton	150.00 — 175.00
Ferro-tungsten, 70-80% per lb. of contained W	gross ton	45.00 — 60.00
Ferro-uranium, 35-50% of U	lb.	1.25 — 1.40
Ferro-vanadium, 30-40% per lb. of contained V	lb.	7.00 — 7.50

**Ores and Semi-finished Products**

Chrome ore, 35-40%, C <sub>2</sub> O <sub>3</sub>	unit	\$0.60 — \$0.85
Chrome ore, 48% and over	unit	1.00 — 1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 — 7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 — 6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	12.00 — 12.50
Fluor spar, gravel, f.o.b. mines	net ton	25.00
Manganese ore, 45% Mn and over	unit	.30 — .75
Manganese ore, chemical (MnO <sub>2</sub> )	gross ton	60.00 — 70.00
Molybdenite, 85% MoS <sub>2</sub> , per lb. of MoS <sub>2</sub>	lb.	.75 — .85
Tungsten, Scheelite, 60% WO <sub>3</sub> and over, per unit	unit	9.00 — 15.00
Tungsten, Wolframite, 60% WO <sub>3</sub> and over, per unit	unit	7.50 — 10.00
Uranium oxide, 96%	lb.	2.75 — 3.00
Vanadium pentoxide, 99%	lb.	6.00 — .....
Pyrites, foreign, lump	unit	.17</td

## INDUSTRIAL

### Financial, Construction and Manufacturers' News

#### Construction and Operation Connecticut

**BRIDGEPORT**—I. Pick, c/o A. E. Fisher, archt. and engr., 373 Fulton St., Brooklyn, N. Y., is having plans prepared for the construction of a 1-story silverware factory. Estimated cost, \$30,000.

**HARTFORD**—The Hartford Rubber Works, Park and Bartholomew Aves., has awarded the contract for the construction of 3 additions to its plant to Stone & Webster, 147 Milk St., Boston. Estimated cost, \$2,225,000.

**STRATFORD** (Bridgeport P. O.)—The Albert-Feck Co., Bruce Ave., will build a 2-story, 67x180-ft. silverware factory. Estimated cost, \$50,000. Work will be done by day labor.

#### District of Columbia

**WASHINGTON**—The Dist. Comrs., Room 320, District Bldg., will soon award the contract for the furnishing of 1 oxy-acetylene welding equipment and supplies for the McKinley Manual Training School.

#### Illinois

**QUINCY**—Lockwood, Green & Co., engrs., 38 South Dearborn St., Chicago, will soon receive bids for the construction of a 3-story, 60x175-ft. drug factory, for the Monroe Drug Co., 601-11 North 4th St. Estimated cost, \$200,000.

**ROCKFORD**—The Rockford Paper Box Board Co., Catherine St., has awarded the contract for the construction of a 3-story, 100x100-ft. paper boxboard factory, to the Holm Page Co., 1604 4th Ave. Estimated cost, \$85,000.

#### Louisiana

**NEW ORLEANS**—The Marland Oil & Refining Co., Ponca City, Okla., plans to construct a large refinery here with the necessary pipe lines to the north Louisiana oil fields; also build and equip a large line of tank steamers. Estimated cost, \$7,000,000. E. W. Marland, Ponca City, president.

#### Maryland

**CURTIS BAY** (Baltimore P. O.)—The Armour Fertilizer Co., 1501 Munsey Bldg., Baltimore, has awarded the contract for the construction of a fertilizer plant on the waterfront, to Westinghouse, Church, Kerr & Co., Inc., 37 Wall St., New York City. Estimated cost, \$2,000,000.

**HAVRE DE GRACE**—E. M. Smith plans to build a brick plant and is in the market for machinery for same.

#### Massachusetts

**MEDFORD**—The trustees of Tufts College plan to construct a chemical laboratory building on the Campus.

**PITTSFIELD**—The General Electric Co. will soon receive bids for the construction of a 1-story, 80x400-ft. enameling plant. C. C. Chesney, manager.

#### Michigan

**HIGHLAND PARK** (Detroit P. O.)—The Maxwell Motor Co., Oakland Ave., has awarded the contract for the superstructure for the proposed 1-story, 315x557-ft. pressed steel plant, to the U. S. Structural Co., 520 Book Bldg., Detroit. Estimated cost, \$450,000.

**MUSKEGON HEIGHTS** (Muskegon P. O.)—The Shaw Electric Crane Wks., McKinney St., Muskegon, plans to construct a 1- and 2-story foundry and machine shop at McKinney and Park Aves. Estimated cost, \$2,000,000. Manning, Maxwell & Moore, McKinney St., Muskegon, engrs.

#### Minnesota

**ST. PAUL**—The Western Chemical Co., Hutchinson, is having plans prepared for the construction of a 3-story, 90x120-ft.

chemical factory on Malcolm Ave., here. Estimated cost, \$125,000. Downs & Eads, 803 Phoenix Bldg., architects.

#### Missouri

**JOPLIN**—A stock company is being organized to build a zinc oxide factory. Estimated cost, \$300,000. Address J. Leopold, secretary of the Chamber of Commerce.

#### Montana

**MISSOULA**—The Missoula Hide & Wool Co., 511 West Main St., is having plans prepared for the construction of a 2-story, 40x200-ft. tannery. Estimated cost, \$25,000. Charles H. Stehling Co., 401 4th St., Milwaukee, Wis., architect and engineer.

#### Ohio

**CLEVELAND**—The Crucible Steel Forge Co. will soon award the contract for the construction of a 1-story, 60x900-ft. rolling mill, heat-treating plant, machine shops and warehouse, on Grant Ave. Estimated cost, \$300,000. D. W. Wells, 6600 Grant Ave., mgr. James H. Herron, West 3rd St., and St. Clair Ave., architect and engineer.

**CLEVELAND**—The Enamel Products Co., Eddy Rd. and Taft Ave., has awarded the contract for the construction of a 1-story, 60x190-ft. factory, to the Crowell-Lundoff-Little Co., 571 Euclid Ave. Estimated cost, \$75,000.

**Macedonia**—The Pyrite Brick Co. has purchased a site and plans to build a 1-story brick plant on same. Estimated cost, \$250,000. Peter Schneider, care of Bldrs. Exch., Rose Bldg., Cleveland, manager.

#### Oklahoma

**GRANDFIELD**—The Uncle Sam Oil Co., 1409 Minnesota Ave., Kansas City, Kan., plans to construct a 1-story refinery at the George Hancock Farm. Estimated cost, \$500,000.

**PRYOR CREEK**—V. V. LONG & CO., consult. engr., 1300 Colcord Bldg., Oklahoma City, is preparing preliminary plans for the construction of a water purification plant, etc., for the city.

#### New Jersey

**HOBOKEN**—The White Metal Mfg. Co., 1006 Clinton Ave., is having plans prepared for the construction of a 6-story, 135x135-ft. factory and a 2-story, 20x80-ft. foundry. J. C. Schaffer & Co., 38 West 32nd St., New York City, architect and engineer.

#### New York

**BINGHAMTON**—The W. R. Hollingshead Co., manufacturing chemists, 148 Oak St., has purchased a site and plans to construct a 4-story factory on same. Estimated cost, \$150,000.

**BROOKLYN**—The Federal Composition Paint Co., 17 Battery Pl., New York City, has awarded the contract for altering a 3-story factory at 258 41st St., to the William Kennedy Constr. Co., 215 Montague St. Estimated cost, \$60,000.

#### North Carolina

**LEXINGTON**—The city will receive bids until Jan. 20 for the construction of a filter house and installation of filter tubs, coagulating basin, etc. Estimated cost, \$500,000. G. C. White, Durham, engineer.

#### North Dakota

**WEBSTER**—The Bd. of Educ. will receive bids until Jan. 20 for the construction of a 2-story, 94x140-ft. school. Laboratories will be installed in same. Estimated cost, \$145,000. Oscar Magnus, clk. Edwins & Edwins, Northwestern Bldg., Minneapolis, Minn., architects.

#### Texas

**FT. WORTH**—The Invincible Oil Corp., 208 West 8th St., plans to build a 5000-bbl. refinery addition in the northern part of the city. Estimated cost, \$500,000. W. R. Spann, 208 West 8th St., archt. and engr.

#### Wisconsin

**SHEBOYGAN**—C. W. Boley, city engr., and the Bd. of Pub. Wks., City Hall, will receive bids until Jan. 19 for purchasing and installing sterilizing equipment for purifying the water in Lake Michigan, used for the city water. Estimated cost, \$11,-000. J. Steinle, clerk.

**TOMAH**—The Tomah Rubber Works, 176 16th St., Milwaukee, has awarded the contract for the construction of a 2-story, 100x100-ft. factory, to Charles Larson, Tomah. Estimated cost, \$45,000.

#### Wyoming

**CHEYENNE**—The Bd. of Trustees of the Memorial Hospital of Laramie Co. will receive bids until Jan. 27 for the construction of a 4-story, 200x200-ft. hospital at 23rd and House Sts., for Laramie Co. An X-ray apparatus and laboratory equipment will be installed in same. Estimated cost, \$300,000.

#### Ontario

**MERRILTON**—The Canadian Steel & Forging Co. is having plans prepared for furnishing equipment for the proposed steel plant addition. Plans include the installation of enameling and pickling equipment. Estimated cost, \$200,000. J. J. Wernette, 441 Houseman Bldg., Grand Rapids, engineer.

**NEWMARKET**—The city is having plans prepared for the construction of sewers in Darcy and Yonge Sts.; also a sewage disposal plant and an activated sludge plant. Estimated cost, \$60,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, engineer.

**TORONTO**—Balwins Limited, Ashbridges Bay, has awarded the contract for the construction of a 1-story, 70x800-ft. steel plate mill at Ashbridges Bay, to Canadian Allis-Chalmers, Ltd., 212 King St., W. Estimated cost, \$200,000.

**TORONTO**—The Oakoal Co., King St., E., has offered the city \$15,000 for its garbage, proposing to erect a plant and make same into fuel briquets. City spends \$175,000 yearly at present on garbage disposal.

## Coming Meetings and Events

**THE AMERICAN CERAMIC SOCIETY** will hold its annual meeting in Philadelphia, Pa., Feb. 23-26. Headquarters are at the Bellevue-Stratford Hotel.

**THE AMERICAN CHEMICAL SOCIETY** will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

**THE AMERICAN ELECTROCHEMICAL SOCIETY** will hold its spring meeting in Boston, April 8, 9, and 10.

**THE AMERICAN ELECTROCHEMICAL SOCIETY**, New York Section, will hold a meeting, Jan. 23, on "Cheap Cyanide and Its Disposition."

**THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS** will hold its spring meeting in New York, Feb. 16-19.

**THE NATIONAL FOREIGN TRADE CONVENTION** will be held in San Francisco, May 12 to 15.

**THE MINING AND METALLURGICAL SOCIETY OF AMERICA** will hold a meeting in New York Jan. 13.

## Industrial Notes

**THE ANHEUSER-BUSCH BREWING CO.** is converting a part of its plant into a factory for the production of bodies for automobile trucks and stake wagons. It will be known as the Busch Body Plant.

**THE FEDERAL RUBBER CO.** of Cudahy, Wis., has opened a sales branch at 1016 Market Street.

**ROGERS, MAYER & BALL** announce the extension of their facilities for the examination and appraisal of oil properties through the addition to their staff of Mr. Carl N. Anderson, formerly engaged with the Illinois Geological Survey and the Gulf Oil Corporation.

**THE AMERICAN STEAM CONVEYOR CORP.**, Chicago, Ill., has added to its sales engineering staff Albert A. Casey, of Cincinnati, Ohio.

**THE LAKEWOOD ENGINEERING CO.**, of Cleveland, Ohio, announces that as an inducement to industrial plant managers, engineers and others to study their inter-department transportation problems and more fully realize how industrial tractors and trucks help to conserve labor and in-

crease production, an offer of three awards, \$1,000, \$500 and \$250, is made for the three best analyses of the application of the Lakewood Tier-Lift Truck. This contest is open to all except employees of the Lakewood Engineering Co. All papers must be in by Jan. 30, 1920, and the awards will be made prior to Feb. 28, 1920. The award committee has been appointed by the Society of Industrial Engineers.

THE RICHARDSON-PHENIX Co., Milwaukee, Wis., announces that its Philadelphia office, which was closed on account of the lubricating engineers in that office going into Government service during the war, is now reopened, and is in a position to give prompt service in all matters pertaining to the scientific lubrication of machinery. George F. Fenno is the manager.

WESTINGHOUSE, CHURCH, KERR & CO., INC., announces the appointment of Russell W. Stovall as consulting engineer, to devote his time to the company's electrical and mechanical works.

THE LINCOLN ELECTRIC Co. announces that Paul M. Lincoln, for many years commercial engineer of the Westinghouse Co., has resigned from that organization, to enter the consulting engineering field, and in that capacity will have active charge of motor application engineering for the Lincoln Electric Co., Cleveland, Ohio.

LOUIS A. DUFFY, recently of the J. Frank Dunbar Co., New York City, and Stephen H. Sears, formerly connected with the Firestone Tire Co., Akron, Ohio, have opened an office at 133 Front St., New York City, as brokers in crude rubber, under the firm name of Duffy & Sears.

THE UNIVERSITY OF ILLINOIS, Urbana, Ill., announces that owing to the meetings of the National Brick Manufacturers' Association and the American Ceramic Society, which have been scheduled for the last two weeks in February, the dates for the short course to be given by the department of ceramic engineering have been fixed for March 1 to March 13, 1920. Programs of the course are now available for distribution.

THE UNITED ELECTRIC CONSTRUCTION Co., INC., announces the opening of its Cleveland (Ohio) office at 558-559 Hippodrome Annex.

THE ELECTRIC FURNACE CONSTRUCTION Co., Philadelphia, Pa., announces that the Vancouver Engineering Works, Ltd., Vancouver, B. C., has given an order for a "Greaves-Etchells" furnace.

DR. FREDERIC DANERTH, consulting chemist and specialist in the industries of rubber and related gums, announces the removal of his offices to the Board of Trade Bldg., 800 Broad St., Newark, N. J.

THE GENERAL FIRE EXTINGUISHER Co., Providence, R. I., was taken over Jan. 1 by a new company—Grinnell Co., Inc. The related industries which the Grinnell Co. takes over consist of fire protection, power and process piping, steam, hot water and gas heating, drying, sales of pipe, fittings, valves and supplies.

WALTER A. ZELNICKER SUPPLY Co., St. Louis, announces that Hugh L. Siegal has been appointed assistant to the president. He was formerly general sales manager for the Ford Roofing Products Co.

THE ELECTRICAL REFRactories Co. is the successor to the Novelty Clay Forming Co., having offices at East Palestine, Ohio.

IVAN P. TASHOF, specialist in inventions relating to the chemical, electrochemical and metallurgical industries, announces the opening of an office in the Victor Bldg., 724 Ninth St., N. W., Washington, D. C., for the practice of patent and trade-mark law.

THE YOCUM LABORATORIES is the new name of the business conducted for many years by John H. Yocom at 325 Academy St., Newark, N. J., which began business Jan. 1, 1920. On May 1 the corporation will take possession of its new laboratory at 168 Court St., Irvington, N. J., which is now being erected under the most recent ideas as to laboratory construction.

THE CREDITORS' COMMITTEE of the British-American Chemical Company, Inc., 42 Broadway, New York City, announce, under date of Dec. 12, 1919, to the creditors, parties to the plan of reorganization and composition agreement, as follows: "The undersigned readjustment committee, acting under the plan for the reorganization of the British-American Chemical Co., Inc., dated Jan. 6, 1919, beg leave to advise you that they became the purchasers of the property and assets of the company named under judicial sale and caused the same to be conveyed to the British-American Chemical Corp. of New Jersey as thereby authorized. The said corporation has been

more conservatively capitalized than the plan referred to contemplated. No mortgage bonds have been issued. The preferred stock is limited to \$250,000, instead of \$400,000, is entitled to 8 per cent dividends instead of 7 per cent, and after July 1, 1920, is convertible into common stock, dollar for dollar, at the option of the holder. The distribution of 10 per cent cash and 50 per cent preferred stock will be made to the creditors parties to the reorganization plan on approval by the court of the final report of the receiver, concerning which you will shortly receive due notice. "I. M. Dittenhofer, W. M. Wadden,  
Committee."

THE AUTOMOTIVE PRODUCTS CORP. of New York, which specializes in the exportation of automotive products, announces that it has secured exclusive sales right for all foreign territories of the products of the Standard Roller Bearing Co. of Philadelphia, covering its roller and ball-bearings. It also announces having completed arrangements to export the products of the New Jersey Car Spring & Rubber Co. of Jersey City. Special attention will be given to the metric sizes, which are in great demand abroad at this time in practically all automobile markets, to replace equipment which has deteriorated or been destroyed during the last five years of war when none could be secured, and of new parts and equipment on thousands of machines now being exported from this country or produced in other markets and for which such equipment is not locally available.

THE BOOTH ELECTRIC FURNACE Co., whose incorporation was announced in these columns recently, has opened up the following district offices with a complete staff of engineers and metallurgists, in connection with the sale of electric furnaces for melting steel, iron, and non-ferrous metals: For New York and New England, Edward B. Stott & Co., Flatiron Bldg., New York City, with E. F. Tweedy, secretary of the company, directly in charge; for eastern Pennsylvania, New Jersey, Maryland, Delaware and southern Atlantic coast states, Northern Engineering Co., 308 Chestnut St., Philadelphia, with F. W. Doran in charge; for northeastern Ohio, western Pennsylvania and western New York, Charles L. Foster, formerly sales manager of the Electric Furnace Co. of Alliance, Ohio, with offices at 879 Arcade, Cleveland, Ohio.

THE MID-CONTINENT OIL, GAS & REFINING Co., with offices in Chicago, Kansas City and Oklahoma City, announces that the Cherry process for producing gasoline by electrochemical means will be used in a 2000-lb. refinery to be constructed at Vernon, Woodson Co., Kan.

THE UNITED STATES STEEL CORP. has been given a contract from the Government of Holland for between 15,000 and 18,000 tons of steel rail for the Dutch railways in East Indies.

THE YORK HARDWARE & BRASS Co. has closed a contract with the American Metallurgical Corp., Franklin Trust Bldg., Philadelphia, for the installation of a 1000-lb. revolving electric furnace of the Weeks type for the melting of brass and copper alloys.

Belgian industries still require raw materials and tools, which are coming in slowly owing to the unfavorable exchange and the difficulty of obtaining credit. Materials for the lining of pits in coal mines are needed, as well as cables, beams and machinery of all sorts; also high resistant galvanized steel wire for cable manufacture. The coke ovens require sulphuric acid and heavy tar oils. Resins, iron ore, billets and pig iron, and machine tools of every description are needed. The glass industry needs sulphate of soda. About 45,000 tons of wood pulp are required, as well as many kinds of chemicals, particularly aniline colors. China clay is in demand.

THE ELECTRIC FURNACE Co., Alliance, Ohio, has just installed nine new Baily Electric Furnaces for melting a wide range of non-ferrous metals and alloys, as follows: The Drew Electric & Mfg. Co., Cleveland, Ohio, has purchased a 105-kw. furnace for melting yellow brass. The Nolte Brass Co., of Springfield, Ohio, has installed a 105-kw. furnace, of 1500-lb. capacity for melting yellow brass. The Kennedy Valve Co., Elmira, N. Y., has installed a 105-kw. electric furnace for red brass. The American Bronze Corp., New York City, has contracted for two 1500-lb. electric furnaces for melting bronze. The Dominion Steel Products Co., Brantford, Ont., Canada, has installed a 50-kw. furnace of 500-lb. capacity for yellow brass. The Deming Co., Salem, Ohio, will melt yellow and red

brass in a furnace of 500-lb. capacity. The Miller Pasteurizing Machine Co., Canton, Ohio, will use its Baily Electric 50-kw. furnace for yellow brass. Landers, Frary & Clark, of New Britain, Conn., will melt aluminum in a 200-lb. of aluminum per hour.

ARTHUR D. LITTLE, INC., chemist and engineer, Cambridge, Mass., through its information department, is planning a series of bibliographic studies, to be circulated among the public, university and special libraries of the United States, and the firms and individuals interested in the various studies. Those in course of preparation are: Chemical Warfare; Alcohol from Waste Sulphite Liquors; Industrial Research; The Automobile and Tractor at the Front; The Electric Furnace; Industrial Laboratories; Molasses; The Chemical Action of Light; Woods and Fibers Used as Paper-Making Materials. Copies of the first three are ready and may be had upon request.

## Manufacturers' Catalogs

THE BLACKMER ROTARY PUMP Co., Petoskey, Mich., has issued the eleventh edition of the "Blackmer Rotary Pump," which is illustrated and described.

THE STAR BRASS WORKS, Chicago, Ill., has recently issued a 12-page bulletin, No. 6, pertaining to its line of small steam and water jet apparatus, comprising steam and water syphons or ejectors, also small steam jet pumps applicable to apparatus requiring vacuum, used as centrifugal pump primers, etc., fully illustrated, also including considerable engineering data involved. Copies will be sent upon request.

THE MONEL METAL PRODUCTS CORP., Bayonne, N. J., announces new booklets, ready for distribution, descriptive of Monel metal and its properties.

THE WHEELER CONDENSER & ENGINEERING Co., Carteret, N. J., calls attention to a new bulletin, No. 112-B, entitled "Condensers, Pumps, Cooling Towers, etc." This bulletin illustrates the latest developments in condenser practice. It shows a surface condenser containing 50,000 sq. ft. of surface. Sixteen condensers of approximately this size are now under construction. These will contain approximately 1,000 miles of Crescent Brand tubing drawn in the large Wheeler tube mill. The bulletin shows photographs of a number of actual installations of surface condensers. It illustrates and describes surface condensers, jet condensers, barometric condensers, the Wheeler-Edwards air pump, the Wheeler rotative dry vacuum pump, the Wheeler steam jet air pump, Wheeler centrifugal pumps for all services, jet condensers, barometric condensers, natural and forced draft cooling towers, feed water heaters, and Wheeler evaporators and driers.

THE J. G. WHITE ENGINEERING CORP., New York City, has published an attractive booklet entitled "Nitrate Number One," which briefly illustrates and describes the design and construction of the nitrate plant No. 1.

THE LEEDS & NORTHRUP Co., Philadelphia, Pa., is distributing Catalog No. 86B on the Optical Pyrometer. This bulletin illustrates and describes the use of the optical pyrometer with the hardening forging furnaces, instructions for using, the general use and theory of temperature measurement.

THE GLENS FALLS MACHINE WORKS, Glens Falls, N. Y., has issued two leaflets on rotary sulphur burners. One gives in a table the various sizes, sulphur burned per hour, approximate weight and floor space, together with a description of a 36 in. by 8 ft. machine. The other leaflet gives a table of sizes and combinations, with rated capacities.

THE STRONG-KENNARD & NUTT Co., Cleveland, Ohio, has issued a functional chart showing results gained by proper safety supervision.

THE AEROIL BURNER Co., INC., Union Hill, N. J., calls attention to a new bulletin describing and illustrating thawing outfits and torches for thawing out frozen cars, pockets, hoppers, pipes, switches, loading gates, chutes, etc.

WALLACE & TIERNAN Co., INC., New York City, has issued a leaflet entitled "Adjustable Orifice for Chemical Solutions."

THE SCIENTIFIC UTILITIES Co., INC., New York City, has published a catalog in which chemical glassware, thermometers and laboratory supplies are listed, which should be useful for the chemist and purchasing agent.